NOVEMBER, 1957
Vol. 11, No. 11

FT food technology

THE JOURNAL OF THE INSTITUTE OF FOOD TECHNOLOGISTS

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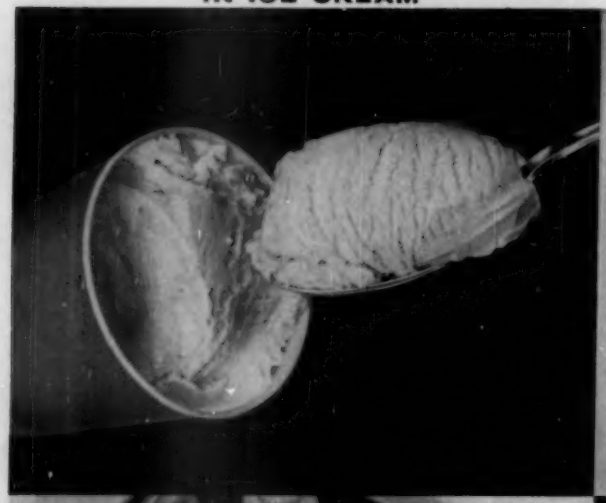

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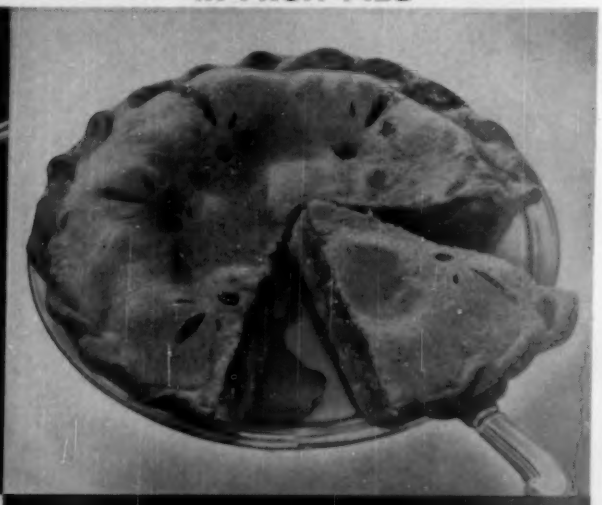

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FT food technology

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CONTENTS

The World I Lived In 541
EMIL M. MRAK

Non-destructive Measurement of Internal Color of Tomatoes by Spectral Transmission 552
GERALD S. BIRTH, KARL H. NORRIS, AND JOHN N. YEATMAN

The SQC Approach to Multiple Correlation and Regression in Food Packaging Research 558
MAE-GOODWIN TARVER AND ANNA MAY SCHENCK

Further Studies on the Preservation of Beef With Chlortetracycline 563
JAMES M. JAY, H. H. WEISER, AND F. E. DEATHERAGE

Factors Affecting Quality of Prepackaged Meat 567
II. Color Studies. B. Effects of Storage Time, Storage Temperature, Antioxidants, Bacteria, Light, Freezing and Fat Upon Color of Product.
JOHN A. RIKERT, LAWRENCE BRESSLER, C. OLIN BALL, AND ELIZABETH F. STIER

Correlation Between Flavor and Number of Microorganisms Associated with Eviscerated Chicken Treated with Chlortetracycline 573
AGNES FRANCES CARLIN, B. ELIZABETH HOLL, AND HOMER W. WALKER

A Survey of the Bacteriological Quality of Frozen Poultry Pies 578
ERCOLE CANALE-PAROLA AND Z. JOHN ORDAL

Application of Work Measurement to the Determination of Fibrousness in Asparagus 583
GEORGE T. BACKINGER, AMIHUD KRAMER, ROBERT W. DECKER, AND ARTHUR P. SIDWELL

Storage Properties of Vacuum-Packed Coffee 586
M. C. MERRITT, B. A. CAWLEY, E. E. LOCKHART, B. E. PROCTOR, AND C. L. TUCKER

Consumer Preference Studies on Apple Sauce: Sugar-Acid Relations 589
E. C. DRYDEN AND CLAUDE H. HILLS

Sorbic Acid as a Selective Agent for Cucumber Fermentations 591
III. Evaluation of Salt Stock from Sorbic Acid Treated Cucumber Fermenations
E. N. COSTILOW

Factors Affecting the Consistency of Cream Style Sweet Corn 595
ROBERT C. WILEY, AARON KORNETSKY, BERNARD A. TWIGG, AND JAMES M. SHRIVER, JR.

Freeze-Dried Meat 599
V. Preparation, Properties, and Storage Stability of Precooked Freeze-Dried Meats, Poultry, and Seafoods
A. L. TAPPEL, RUTH MARTIN, AND ESTHER PLOCHER

Time-Temperature Tolerance of Frozen Foods 604
IX. Effect of Time and Temperature on Color Distribution in Retail Packs of Frozen Raspberries
D. G. GUADAGNI AND C. C. NIMMO

Effects of Packaging on Partially Baked Rolls: Observation on the Retention of Riboflavin, Moisture and Flavor 608
J. J. BIRDSALL AND L. J. TEPLY

Tenderness and Juiciness of Veal Loin Roasts and Chops 611
A Comparison of Methods of Measuring Those Qualities
FLORA HANNING, R. W. BRAY, N. N. ALLEN, AND R. P. NIEDERMEIER

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THE TECHNICAL ARTICLES IN BRIEF

Instrumentation *Fibrousness in asparagus*

Application of work measurement to the determination of fibrousness in asparagus. George T. Backinger and Amihud Kramer.

The recent adaptation of shear resistance instruments for electrical indicating and recording provides the possibility of obtaining not only maximum force, but complete force displacement curves which may be integrated in terms of pounds-inches of work. Data are presented on asparagus, showing that such work measurements may be adjusted more precisely for variations in sample size and speed of stroke. They are not influenced by the stratification or the size of units in the sample and provide information not only on average texture but also the distribution and variability of textural quality within the sample. (See page 583.)

Fermentation *Cucumbers*

Sorbic acid as a selective agent in cucumber fermentations. III. Evaluation of salt stock from sorbic acid treated cucumber fermentations. Ralph N. Costilow.

Gaseous fermentations by yeasts are often responsible for bloater spoilage of cucumber salt stock. A 3-year study on the use of sorbic acid in cucumber fermentations to inhibit yeast growth is reported. This involved a total of 141 experimental fermentations testing sorbic acid concentrations ranging from 0.01 to 0.10%. Salt stock from these fermentations was evaluated with respect to percent bloaters, firmness, and color. In most instances, sorbic acid treatment reduced the percentage of bloaters, but it did not completely eliminate them. There was no significant effect of the treatments on the firmness, and sorbic acid levels below 0.05% did not affect the color of the stock. However, a definite bleaching was observed frequently with 0.1% and occasionally with 0.05% sorbic acid. (See page 591.)

Flavor *Stored, vacuum-packed coffee*

Storage properties of vacuum-packed coffee. M. C. Merritt, B. A. Cawley, E. E. Lockhart, B. E. Proctor, and C. L. Tucker.

Effect of storage temperature and length of storage on can vacuum, volatiles as monocarbonyl remaining in the grounds, and flavor acceptance in the brew was investigated in vacuum-packed coffee over a period of 27 months. Vacuum in the cans and volatile monocarbonyl remaining in the grounds decreased with increasing temperature of storage and length of storage but tended to reach an equilibrium at approximately one year of storage. That a state of equilibrium was being established between can vacuum and volatiles is indicated. Flavor comparison of brews prepared from stored coffee samples indicated no significant change had occurred with time and temperature of storage. Statistical evaluation of flavor score at 27 months by analysis of variance showed no significant variations due to temperature of storage. (See page 586.)

Antibiotics *Broilers*

Correlation between flavor and number of microorganisms during storage of fresh, cut-up broilers. Agnes Frances Carlin, B. Elizabeth Holl, and Homer W. Walker.

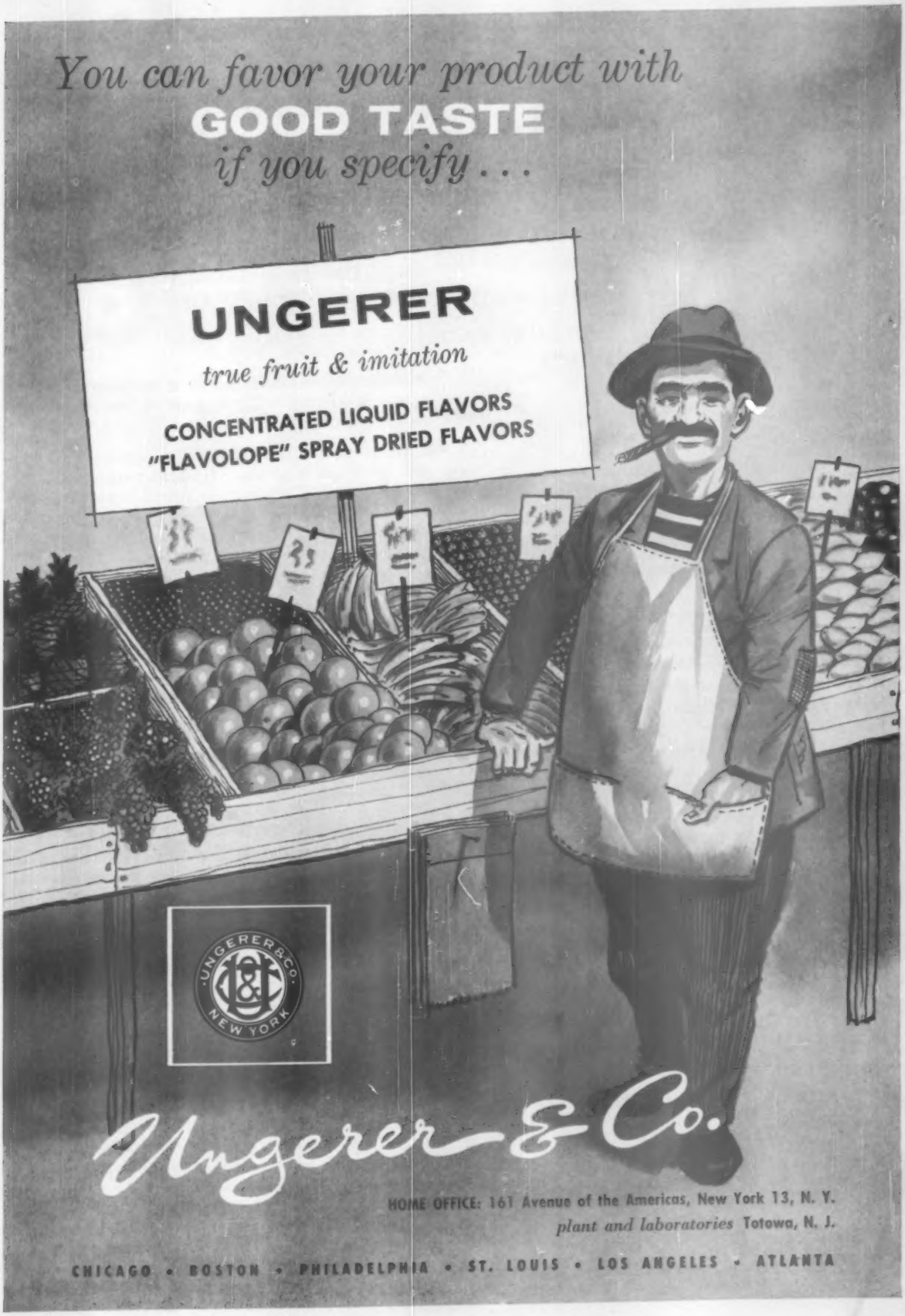
Studies by a number of investigators have shown that certain antibiotics will markedly retard development of bacteria and fungi and thus prolong the storage life of the product. Any increase in the time that meat is stored raises the question of the effect of this treatment on the organoleptic qualities of the food. This investigation was conducted to determine whether or not there was a correlation between the flavor and the number of microorganisms that occurred on untreated control or on antibiotic-treated, fresh, cut-up broilers stored in a commercial refrigerated display case. Untreated control and antibiotic-treated whole birds were stored for various periods of time in crushed ice until removal for cutting, packaging, and storing in the refrigerated case for 24 to 72 hours. Comparisons were made between different types of packaging material; a vacuum-type package was included in the study. Bacterial counts were made initially and during storage. A taste panel evaluated the quality of the broilers. (See page 573.)

Measurement *Consistency of sweet corn*

Factors affecting the consistency of creamed sweet corn. Robert C. Wiley, Aaron Kornetsky, and Bernard A. Twigg.

Water, starch in the cream component, and added starch are the factors chiefly responsible for the consistency of the final processed pack of creamed sweet corn. Relationships between consistency at the filler and processed consistency after 1, 3, 6, and 12 months storage show correlation coefficients of around +.90. Filler consistency values of about 9 Adams (165° F.) gave consistency values after 90 days around 11.0

November Cover. Drying foods in the frozen state, known also as sublimation and lyophilization, gives promise of becoming of great industrial importance on account of the enhanced quality of the dehydrated product resulting. Food scientists and technologists have long been engaged in the basic and applied research required to bring freeze drying to general commercial acceptance. Shown on the November cover are freeze-dried steaks, all the way from freezer to container to frying pan. Photographs by courtesy of Armour & Company, Chicago.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which were considered top fancy. A nomograph showing the relationships between starch and water with a correction for AIS indicated that top fancy consisteney after 90 days could be acquired with the combination of 1.47% added starch with the 30% water level and a 17.44% AIS cream component in the blending tank. For each change ± 2% AIS from the 17.44% value, one should adust the Adams consistometer values 1 point. AIS of the cream component was found to be more highly related ($r = +.652$) with consisteney after storage than the AIS of the kernel component ($r = +.285$). (See page 595.)

Instrumentation *Tomato color*

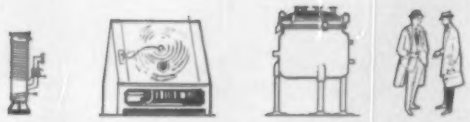
Non-destructive measurements of the internal color of tomtaoes. Gerald S. Birth, Karl H. Norris, and John N. Yeatman.

Instrumentation is described for measuring the spectral transmission of whole fruits and vegetables. Further application of this technique to a practical problem, i.e., measuring the average color of tomatoes is described. Spectral transmission curves of intact tomatoes in the 400 mμ to 900 mμ region of the spectrum are included. Criterion for evaluating the red color of tomatoes is a ratio between the transmission of light at two different wavelengths, i.e., 620 mμ and 670 mμ. Criterion for green tomatoes is a ratio between the transmission at 520 and 545. A portable field instrument to make these measurements is described. A correlation coefficient in the order of 0.95 between the transmission measurement and a measure of the color of the tomato juice as measured by the Hunter Color Difference Meter is shown as an indication of the practicability of this type of measurement. (See page 552.)

Statistical evaluation *Packaging*

SQC approach to the use of multiple regression in food research. Mae-Goodwin Tarver and Anna May Schenck.

Multiple regression and correlation techniques are valuable in solving certain food packaging problems. When a combination of many measurable factors produces one result, they are the only methods which will evaluate the relative effect of each. Application of these techniques is usually a time consuming, lengthy process when many factors are present. However, in the majority of cases, a small number of the factors account almost entirely for the total correlation. Using the SQC approach it is possible to hunt for small combinations of factors which will add almost completely to the total multiple correlation coefficient. The formal approach has been either to delete factors one by one from the complete matrix until a dropping off point is reached, or to test the significance of the regression coefficients using Gauss multipliers, and to delete those not significant. The authors deviate from the formal approach by running the complete matrix of all factors to find the maximum value of R^2; then, starting with the factor having the highest simple cor-



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relation coefficient, remaining factors are added one by one until the maximum value of R^2 is approached, indicating that dominant factors have been located. This method is illustrated with data accumulated in container research laboratories. The approach can be checked by an analysis of variance for complete components. Application of these techniques to a seven-factor food research problem is shown and the technical interpretation of the statistical results is also presented. (See page 558.)

Freeze-drying *Meats, poultry, seafoods*

Freeze-dried meat. V. Preparation, properties, and storage stability of precooked freeze-dried meats, poultry, and seafoods. A. L. Tappel, Ruth Martin, and Esther Plocher.

Precooked freeze-dried beef, pork, veal, lamb, chicken, turkey, salmon, tuna, shrimp and oysters were prepared. Time required for freeze-drying was mainly a function of thickness. Rehydration in 212° F. water at atmospheric pressure was poor. Some of the meats, poultry, and seafoods had good organoleptic properties; most of them were stable for 6 months' storage at 70° F. and 100° F. Samples stored at 130° F. developed a desirable flavored browning during the first 2 months and began deteriorating thereafter. Water vapor equilibria of precooked freeze-dried beef and pork are favorable for freeze-drying and use of in-package desiccation. (See page 599.)

Freezing *Raspberries*

Time-temperature tolerance of frozen foods. IX. Effect of time and temperature on color distribution in retail packs of frozen raspberries. D. G. Guadagni and C. C. Nimmo.

A procedure for the determination of color in frozen raspberries is described. Data presented show that sirup color increases markedly with storage time for temperatures of 10° F. and above but changes only slightly at 0° F. or lower. For uniform lots of berries sirup color is a useful index of the accumulated time-temperature experience of a given sample. In samples differing with respect to original berry color, wholeness, and fruit to sirup ratio, determination of the sirup color alone is not sufficient for a reasonable estimation of time-temperature experience. In these instances color determinations on both sirup and drained berries are necessary. During storage at 20–25° F. expression of fruit and sirup color as a ratio tends to eliminate variations due to original color and processing conditions, and thus permits evaluation of temperature history irrespective of these variables. (See page 604.)

Measuring tenderness, juiciness *Veal roasts, chops*

Tenderness and juiciness of veal loin roasts and chops with a comparison of methods of measuring those qualities. Flora Hanning, R. W. Bray, N. N. Allen, and R. P. Niedermeier.

Press juice determinations may be made on either warm or cold cubes of lean meat or on ground cold meat. There was little difference in methods except for the greater amount of expressible liquid from warm samples and the lesser amount absorbed by the pad than was lost in weight from the meat. Under conditions of this test, measurement of force to grind meat from braised veal chops showed no significant difference between feeding methods. Shear force values and 2 methods of evaluation of tenderness by a judging panel gave statistically significant differences of the same trend between various methods of feeding calves. Variation between judges was marked, particularly when number of "chews" was the criterion used. Feeding calves on whole milk with iron and copper addition produced more tender veal than the three other feeding methods. The more intense red color of the bones is believed not a disadvantage when veal is thoroughly cooked by braising. (See page 611.)

Consumer preference *Sugar-acid relations*

Consumer preference studies on apple sauce: sugar-acid relations. E. C. Dryden and Claude H. Hills.

The higher the sugar content of a sauce, the higher the acidity required for the optimum flavor effect. Likewise, the higher the acidity, the higher the sugar required. However, optimum Brix-acid ratio was not the same in all tests. Changes in sugar content affect the degree of preference to a greater extent than proportionally equivalent changes in acidity. Data indicate the sauce most preferred to be one containing about 0.45% acid, with a Brix value of about 22, that is, with 0.05% more acid and 4% more sugar than the standard sauce chosen for the tests. The panel of tasters employed in these tests was smaller than that usually called for in a consumer-preference test. Facilities for more adequate sampling of the consuming public were not available. However, this work indicates that the quality and uniformity of apple sauce could be improved by regulating the Brix-acid ratio. (See page 589.)

Bacteriology *Frozen poultry pies*

A survey of the bacteriological quality of frozen poultry pies. Ercole Canale-Parola and Z. John Ordal.

Precooked frozen chicken and turkey pies as produced by 5 different manufacturers were examined quantitatively for bacterial contamination. Unbaked frozen pies differed in amount of bacterial contamination among the 5 brands, probably reflecting the nature of the sanitary and technological methods followed by the 5 manufacturers. Of the 40 unbaked pies tested, 20 had total counts above 100,000 per gram, and 18 had coliform counts above 10 per gram. Enterococci were present in all samples tested and coagulase-positive staphylococci were detected in 37 of 40 pies tested.

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Five Salmonella cultures were isolated from the unbaked pies. When the pies were baked, data indicated that baking time and temperatures specified for some of the brands were not sufficient to cause destruction of non-spore forming organisms. Since frozen pies contain microorganisms which have a food poisoning potential, it is suggested that (a) efforts be directed towards introducing improved technological and sanitary measures in preparing these products, (b) further consideration be given to the baking times suggested on each package, and (c) pie crusts be formulated which brown more slowly at the baking temperature, thus encouraging a longer baking time. (See page 578.)

Packaging effects *Partially baked rolls*

Effects of packaging on the riboflavin, moisture, and flavor of enriched partially baked rolls. J. J. Birdsall and L. J. Teply.

Studies were conducted to compare the relative effects of 3 wrapping materials on retention of riboflavin, moisture, and flavor in partially baked rolls. Results of storage of the rolls under 100 foot candles of light revealed significant losses in riboflavin during the first 7 days of storage when packaged in typical commercial cellophane and waxed paper. Such losses were not observed in rolls packaged in aluminum foil. Slight losses in moisture were quite comparable among the three test packages. Definite, undesirable changes in flavor occurred in the rolls after 7 days' storage when packaged in cellophane. Foil-wrapped rolls showed better retention of their original flavor and texture than did rolls wrapped in waxed paper and cellophane. (See page 608.)

Biology *The yeasts*

The World I Lived In. Emil M. Mrak.

The Appert Award address (1957). A discussion of what yeasts are, how they reproduce, where and with whom they live, and some of the things they do to certain foods. The observations made constitute the highlights of many years of research, in association with Dr. H. J. Phaff and other colleagues, at the University of California. (See page 541.)

Antibiotics *Beef*

Further studies on the preservation of beef with chlortetracycline. James M. Jay, H. H. Weiser, and F. E. Deatherage.

The phenomenon wherein low concentrations of chlortetracycline inhibits resistant strains of *Proteus*, *Pseudomonas*, and strains of certain other genera in beef but not in complete nutrient media was further characterized. Oxytetracycline and tetracycline were also found to act in a similar manner, but not as effectively as chlortetracycline. Streptomycin, chloramphenicol, and penicillin did not act similarly against the same organisms. Significant inhibition of strains of *Proteus vulgaris* could be observed with inocula as high as 65,000 per gram. Inocula of over 150,000 per gram were not consistently inhibited by 5 p.p.m. chlortetracycline in beef. Of a group of resistant bacteria commonly associated with beef around 70% were found to be affected by 5 p.p.m. chlortetracycline. Effectiveness of the tetracycline antibiotics in retarding spoilage in meats may be due to their ability to disturb the ionic balance in the product. (See page 563.)

Packaging *Effect on product color (meat)*

Factors affecting the quality of prepackaged meat. II. Color studies. B. Effects of storage time, storage temperature, antioxidants, bacteria, light, freezing and fat upon color of product. John A. Rikert, Lawrence Bressler, C. Olin Ball, and Elizabeth F. Stier.

A continuation of the studies on packaging materials, packaging conditions, and storage conditions to determine a means of inhibiting quality degradation of prepackaged meats. The quality attribute, color, is herein studied. Packaging materials studied in connection with color retention in prepackaged meat were films, including cellophane, cellulose acetate, triethene, vinylidene copolymer, polyethylene, and various laminates. (See page 567.)

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Reflections on a Career with FDA

The Babcock-Hart Award Address

E. M. Nelson

Director, Division of Nutrition, Bureau of Biological and Physical Sciences, Food and Drug Administration, Washington, D. C.

I WISH TO REITERATE my statement of appreciation for having been selected to receive the Babcock-Hart Award. I express my thanks to the Institute of Food Technologists and to the Nutrition Foundation. I have many friends in this audience engaged, directly or indirectly, in the food processing industry. Some of you have come to the Food and Drug Administration to discuss problems with which you have been confronted, and those that have dealt with nutrition have been referred to me. Thus, my office has served as a kind of clearing-house for information. During these conferences I have received many ideas that have helped to clarify my thinking on problems of mutual interest. I have valued these discussions also, because they have permitted me to keep in touch with developments in food processing, and because through them I have formed many valued friendships.

Dr. E. M. Nelson, Recipient of the Babcock-Hart Award, Nutrition Foundation, Inc., Donor.

We have witnessed a major revolution in food technology in the past thirty years. I began my career in the Federal service in the Department of Agriculture in 1926, and my work has been such that I have seen these developments at first hand. I wish to discuss with you briefly some of these developments in which I took an active part. As scientists we are all aware of the fact that discoveries are usually the results of the efforts of more than one person. In fact, it has been said that discoveries are a product of the times rather than the product of the work of one individual. I wish to state that I have had the benefit of very helpful guidance from my superiors, and also full cooperation from my associates, and I must pay tribute to them for any efforts that have led to my appearance on this occasion.

[a] The Babcock-Hart Award Address, presented before the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 14, 1957.

VITAMIN D MILK—A MAJOR ANTIRACHITIC

I was associated with Dr. Steenbock at the time the observation was made that vitamin D could be produced in foods by exposing them to ultraviolet light. This led to the use of irradiation in the production of vitamin D milk, a development that had a great impact on the public health. In 1920, and shortly thereafter, surveys had led to the conclusion that in large cities along the Eastern seaboard 75 to 80 per cent of the infants had rickets. This disease, which manifests itself by various bone deformities, is not serious in the sense that it leads to intense suffering or death, but when it is realized that most cases of rickets in the female lead to deformities of the pelvis which interfere with normal childbirth, the disease assumes much greater importance.

Leaders in the study of rickets such as Dr. Alfred Hess of New York, and leaders in the field of nutrition such as Dr. Lafayette B. Mendell, urged that provision be made for the incorporation of vitamin D in milk as an effective way to prevent rickets. Milk had long been regarded as a food that should not be tampered with, and most states had laws prohibiting the addition of any substance to milk. Most state-enforcement officials had been so thoroughly indoctrinated with this principle that they felt any exception to this principle would lead to a serious breakdown in the enforcement of the law. Irradiated milk, that is, milk exposed to ultraviolet rays, presented no particular problem so far as the sale of a milk with increased vitamin D activity was concerned, but control of the vitamin D content of milks was a matter that had to be considered seriously. State control laboratories were not equipped to make vitamin D assays and arrangements were made with universities, experiment stations, and commercial laboratories to make the necessary examination. The cooperation of the industry in its efforts to distribute a uniform and dependable product was an important factor in the success of this venture. This was done before standards had been promulgated. After the passage in 1938 of the Food, Drug, and Cosmetic Act, evaporated milk was the fourth food to be standardized and provisions were made in the standard for inclusion of vitamin D. While other measures were taken to prevent rickets, it is certain that the widespread practice of fortifying milk with vitamin D was one of the most effective, and rickets is no longer a health problem. Medical schools now have difficulty in finding enough cases to demonstrate the disease to students.

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ENRICHED FLOUR AND THE SEARCH FOR STANDARDS

You will no doubt be interested in some of the problems we faced in establishing standards for enriched foods.

By 1940 when a standard for flour was being considered, there had grown up a substantial practice of adding vitamins to flour and bread, principally vitamins B_1 and D. Representatives of the milling industry presented various proposals for the addition of vitamins to flour, but except for vitamin B_1, there appeared to be no uniformity of opinion with respect to the vitamins to be added. It was quite generally agreed that there should be a separate standard for flour to which vitamins and possibly minerals were added. My views seemed to have an important bearing on the standard that was finally adopted.

My first consideration with respect to the addition of a vitamin to flour was that such addiiton should serve a useful purpose. In this matter the language of the law was a guide. The Secretary has authority to promulgate a standard for a food if it will promote "honesty and fair dealing in the interest of consumers". If it could be established, either by clinical studies or by dietary surveys, that a significant segment of the population did not receive a sufficient quantity of a vitamin, then it would seem to be in the interest of consumers to provide that vitamin in larger quantities by adding it to a food. But the food in question must be a suitable medium or vehicle for the vitamin so that it would be preserved until the food was consumed. Also, the food in question must be one that reached those groups whose diets were deficient. It was important to incorporate the right amount, that is, an amount that would be beneficial but not so much that the vitamin would be wasted. Testimony had been introduced to the effect that the average daily per capita consumption of flour was six and one-half ounces. This quantity of flour provides about one-fourth of the average daily caloric requirement for an adult. On this basis it seemed to me that six and one-half ounces of flour should supply not less than one-fourth of the minimum daily requirement for the vitamin, and there seemed to be no purpose in adding more than the minimum daily requirement to each 6½ ounces of flour. This proposal appeared to provide a reasonable basis for limiting the number of vitamins that might be added to flour, and a limit as to the amount that should be added. The same consideration was given to minerals. In accordance with these views, evidence was adduced to provide a basis for adding to flour, thiamin, riboflavin, nicotinic acid, and iron. The evidence with respect to calcium and vitamin D was not so clear since there was no satisfactory way of determining, by clinical methods, a calcium or vitamin D deficiency in adults. Dietary surveys that had been made indicated that calcium failed to meet the requirements accepted by most nutritionists. There was very little evidence relating to the calcium and vitamin D requirements of older children and adults. It seemed probable that in the northern latitudes of this country sunshine would not provide suffiicent vitamin D. For

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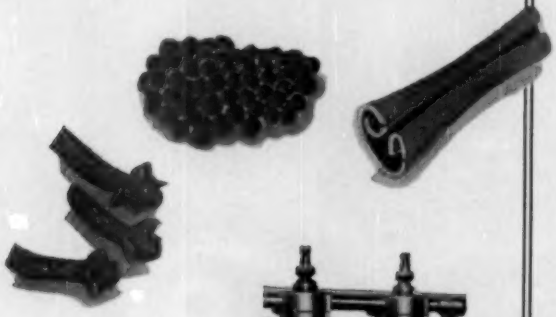

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these reasons, calcium and vitamin D were made optional ingredients of flour. There was some objection to including riboflavin as a required ingredient on the grounds that this vitamin was not immediately available in sufficient supply to fortify all flour. There was insufficient information with respect to the nicotinic acid content of flour. The extent to which thiamin was lost in the baking of bread had not been thoroughly studied, and it was found that the losses were greater than had been estimated. But these matters were resolved by postponing the effective date for the riboflavin addition, and by holding a further hearing at which additional evidence was received with respect to the nicotinic acid content of flour and the destruction of thiamin in the baking of bread. Baking losses were important because the standard contemplated for enriched bread was based on the standard for enriched flour. It was assumed that enriched bread could be made by using enriched flour.

Much consideration was given to the choice of a name for flour with added vitamins and minerals. The name "enriched flour", proposed by a representative of the industry, found acceptance by the Food and Drug Administration, and grew rapidly in popularity.

Niacin. Another troublesome matter arose in that the term "nicotinic acid" for a substance to be included in a food was considered objectionable. To consumers this name implied the presence of nicotine and also of an acid—rather unpleasant implications for an article of food. The law requires that the ingredients of a food shall be listed by their common or usual names. Nicotinic acid is the substance that prevents or cures pellagra, but it had never been recognized as a food constituent until 1937, when its place in nutrition was convincingly demonstrated. The Committee on Nomenclature of the American Institute of Nutrition was asked to suggest a synonym to be used on foods. The term "niacin' was adopted upon the recommendation of a committee consisting of Drs. Spies, Sebrell, and Elvehjem, three investigators whose work had led to estabishing the importance of nicotinic acid as a nutrient.

In addition to wheat flour, there are the milling products of corn and rice which are used interchangeably with flour in our diets in various parts of the country. Standards have been established for enriched cornmeal and enriched corn grits, and standards for enriched rice are now under consideration by our Food Standards Branch. These enrichments have all followed the same pattern with respect to the amounts and kinds of nutrients in the food consumed, with the result that the term "enriched" has acquired a special meaning in connection with these nutritionally-improved foods. From the standpoint of consumer education and consumer understanding, it is important that this pattern be maintained.

You will agree, I am sure, that the activity of establishing standards for foods, of which there are at present a large number, is an important one, both for federal- and state-regulating agencies and for the food industry. Such standards are not only in the interest of honesty and fair dealing to the consumer, but to the advantage of an orderly commerce and improved quality of such food products. The fear has been allayed that setting standards would inhibit progress in the development of new processing methods. We are proud of the progress that has been made in the supply of foods of the highest quality and the greatest variety. My interest has always been one of helping to maintain the best possible nutritional value of our food supply.

"MINIMUM DAILY REQUIREMENTS"

The d[illegible]ting of regulations under section 403(j) that wo[illegible] fulfill the requirements of the law was a real task. These regulations have had an important impact on the practices of the food industry. Section 403(j) reads: "A food shall be deemed to be misbranded if its purports to be or is represented for special dietary uses, unless its label bears such information concerning its vitamin, mineral, and other dietary properties as the Secretary determines to be, and by regulations prescribes as, necessary in order fully to inform purchasers as to its value for such uses". There had been no precedent for this kind of legislation and the language was new. If the special dietary use was based on vitamin content, a requirement for a statement of vitamin content was necessary. But how should it be stated? If it were stated in units, micrograms, or milligrams would it fully inform the purchaser? We thought not. We decided that if minimum daily requirements for vitamins could be established, the vitamin content of the product might be stated in terms of the percentage of the minimum daily requirements in the reccmmended intake. This was done, and since food supplements of various kinds are widely used and the vitamin content in ordinary foods is frequently stressed in promoting their use, this type of labeling has had much educational value. The same provision was made for those minerals in which the diet was most likely to be deficient.

FOODS FOR DIETARY USE

Regulations have also been established for infant foods, foods used in the control of body weight, low sodium foods, foods containing nonnutritive substances, and foods having reduced allergenic properties. If a food purports to be, or is represented as, a food for special dietary use for infants by reason of simulation of human milk, or as a partial or complete substitute for human milk, the label must bear information not only as to the nutrients present, but also information with respect to those nutrients that may not be present in sufficient quantities to meet the requirements of the infant. Foods used in the control of body weight or dietary management with respect to disease must bear a statement of the protein, fat, and carbohydrate content and, in addition, any

special information that is important in the management of disease. If the sodium content of a food is low or has been reduced, and its use is based on low sodium content, the label must bear a statement of the sodium content in milligrams per hundred grams of food, and also a statement of the number of milligrams of sodium in an average serving of the food. If the food is offered for use in the control of disease by virtue of a reduced sugar content and the addition of artificial sweetening, the label must declare that fact. If a food is alleged to be of special use because of reduced allergenic properties, there must be declaration of each ingredient in sufficient detail to inform the purchaser and the food is not eligible for the exemption that added spices, flavors, and colors may be declared as such.

Prior to the last session of Congress, the establishment of, or the amendment to, a regulation was a rather laborious and time-consuming process. It was necessary to draft a proposed regulation, then publish an announcement of a public hearing at which testimony would be taken to adduce evidence upon which a regulation could be based. After the conclusion of the hearing it was necessary to study the record carefully to see what kind of a regulation could be based on the testimony, and then study the proposed regulation from a legal and administrative standpoint. The so-called Hale Amendment, which was passed by the last Congress, greatly simplified the revision of regulations. This amendment provides that the Secretary may publish a proposed order, and if there is no controversy the regulation can be promulgated without holding a public hearing. This procedure has been followed in our recent efforts to establish a minimum daily requirement for niacin and to revise the present minimum daily requirement for riboflavin. Comments have been received on the proposals and are now under consideration before publishing a final order. Further amendments of the regulations covering foods for special dietary use are also being studied, and it is hoped that they can be handled in the same expeditious manner.

These problems relating to milk, enriched foods, and foods for special dietary use represent the type of activities in which I have been engaged. Their full impact on the food industry and upon the public health can be better evaluated with the passage of time. There are many stimulating problems ahead of us.

SOME IMPRESSIONS OF BABCOCK AND HART

I think you will be interested in my impressions of S. M. Babcock and E. B. Hart. These men were the best of friends and had much in common, but they operated quite differently. For one thing, they were both fond of sports. I entered the University of Wisconsin in February 1914. The first night I was in Madison a friend invited me to attend a basketball game. I was much interested in seeing in action the team that had not lost a game in three years and accepted the invitation. Between halves I asked my friend if he knew the distinguished gentleman with the snow-white Van Dyke beard sitting directly across from us. "That," he said, "is Professor Babcock, the inventor of the Babcock fat test, and sitting next to him is Professor E. B. Hart, his successor as Chairman of the Department of Agricultural Chemistry. You will see them at every game sitting in the same seats." Professor Babcock was Professor Emeritus when I first met him. I knew Professor Hart much more intimately. He became my advisor at the end of my second year. Later, when I had been appointed to the staff, Professor Babcock, then retired but active, would arrive at the laboratory about nine o'clock with a Chicago *Tribune* in his hand. He went directly to Professor Hart's office and the subject for discussion was usually found on the sports page of the paper. He was always amused when a sportswriter's prediction of the outcome of a sports event went astray, and such an occasion brought forth a burst of laughter that fairly rang through the halls of the building. I began many a day's work on this cheerful note.

Professor Babcock was a brilliant scientist who had a most inquisitive mind, but he lacked the thoroughness of Professor Hart in writing up his findings and reporting them for future generations. Professor Hart's operations were orderly and methodical in all directions. He discussed with his associates plans for their future work, outlined them carefully, and saw that they were followed in every detail. As soon as one piece of work was completed the observations were written up for publication. He supervised the work in every detail. Before going to his office each morning he visited the poultry, swine, and cattle quarters to observe the progress of the animal experiments. Every morning and afternoon he made a complete round of the building and spoke to members of his staff and graduate students, and took notes of anything in the building that needed repair. In these rounds of the building he did much to stimulate the thinking of his graduate students. He could always ask questions that led one to seek further information for his own guidance, and he had a particularly effective line of questioning for a student who seemed to be so well informed that he knew all there was to know about the subject at hand. Among his close friends Professor Hart was a most interesting conversationalist and raconteur. His stern demeanor of the classroom disappeared completely, and he could be a most entertaining host.

Neither of these men sought publicity. Professor Babcock became very well known because of the practical importance of his milk fat test, but his modestly and diffidence were not typical of one who craves the spotlight. Professor Hart was outspoken against newspaper publicity of scientific developments, and news reporters soon learned that they were not welcome in his office. He told me that scientific findings should be published in scientific journals. "In time," he said, "that which is useful will sift down to the level of application. That which is applicable to animal nutrition should be communi-

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Professor Hart was a wonderful teacher and those who studied under him had the utmost respect for his opinions. A considerable number of his former students now occupy important positions in industry. As I look back over my contacts with the industry I am conscious of many friends who received their training under Professor Hart. This has made my task more pleasant. I have always enjoyed pleasant relationships with the industry, but it is a happy occasion when those of us who have a common bond get together.

WE HAVE A COMMON AIM

I am convinced that many of the vexing problems that arise in the application of the Food, Drug, and Cosmetic Act to the food industry will be solved amicably if we, as scientists, continue to discuss our findings in an informal way. We know that of the new discoveries in this field only those that serve a useful purpose will survive. I believe that we have a common aim in producing and labeling food products to the benefit of the consumer.

It is comforting for me to think of the words of the Chinese philosopher who said, "A man who is in public service is fortunate. His errors will be pointed out to him", but the attention which your accolade gives to accomplishments gives confidence as well as comfort.

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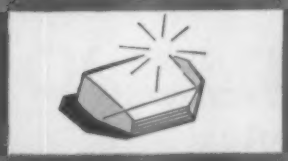

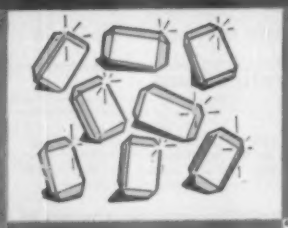
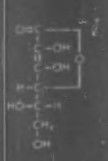

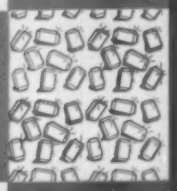
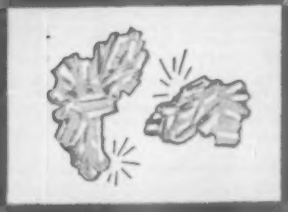
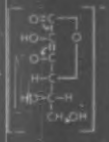

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DATA ON PARTICLE FINENESS

Based on U.S.P. XV-pages 934-5, N.F. 10, pages 702-3; ◆Langes Handbook of Chemistry 9th Edition, page 911

The fineness of "powders" is described in both the U.S. Pharmacopeia and National Formulary in terms which are related to the number assigned to a standard sieve made of woven wire cloth. The size of wire, and sieve opening are standardized together with permissible variation in both average and maximum openings.

Sieve Number	Sieve Opening in Microns	Sieve Opening Mm.	Permissible Variation in Average Opening Per Cent	Permissible Variation in Maximum Opening Per Cent	Wire Diameter Mm.
50	297	0.297	± 5	± 25	0.170-0.253
100	149	0.149	± 6	± 40	0.096-0.125
*200	74	0.074	± 7	± 60	0.045-0.061
*325	44	0.044	± 5	± 60	0.036

Standards are established for defining the fineness of powdered chemicals, together with a technique for determining the uniformity of fineness. The types of powders described in the U.S. Pharmacopeia and National Formulary do not represent the full range of particle sizes commercially available. No procedure is given for the determination of particle size in the "ultra-fine" or "micro powder" range, sometimes referred to as No. 325. This requires a sedimentation method and measurement in microns. Ordinary sieving methods are inaccurate.

The variation possible in the standard sieves plus such variables as the motion applied to the screen and physical characteristics of the powder being screened affect accuracy and duplicability of screening tests. Particle size specifications based on mesh sizes must always be regarded as nominal rather than as strictly accurate limits of particle size and distribution.

SODIUM *l*-ASCORBATE** 'Roche'

This is the sodium salt of *l*-ascorbic acid. It is available as an odorless, tasteless, anhydrous, fine white powder or fine granular substance.

The antiscorbutic activity is in molecular proportion to *l*-ascorbic acid, one milligram of the sodium salt being equivalent to 0.889 milligram of the acid, or one milligram of the acid equivalent to 1.124 milligrams of sodium *l*-ascorbate.

Highly soluble in water—62 grams/100 ml at 25°C, 78 grams/100 ml at 75°C. Aqueous solutions are unstabile, easily oxidized on exposure to air, or other factors which affect *l*-ascorbic acid.

The pH of a sodium *l*-ascorbate solution is from 5.6 to 7.+ as compared with a pure *l*-ascorbic acid solution at pH 2.3-2.5. The more neutral characteristic of the sodium salt recommends it for high dosage oral forms where gastric sensitivity to lower pH might be undesirable. It is useful in combination with ingredients which would react unfavorably under more acid conditions. Products can be buffered to a suitable pH by combining sodium *l*-ascorbate and ascorbic acid together.

Commercial forms of sodium *l*-ascorbate are not recommended for preparation of parenteral solutions. It is more satisfactory to prepare suitably buffered solutions of 'Roche' ampul type *l*-ascorbic acid, using sodium bicarbonate according to the special Roche method described in our technical brochure, "Notes on Vitamin B, and Vitamin C Parenteral Solutions."

Sodium *l*-ascorbate is of value as an antioxidant for use in comminuted meats and in curing pickles for hams, bacon, and corned beef. Because it is the salt of *l*-ascorbic acid (vitamin C), a substance naturally occurring in meats and identified in the U.S. Pharmacopeia, it may be preferred to antioxidants in the "chemical additive" class.

THESE PRODUCTS ARE FOR ANTIOXIDANT USE ONLY. IF USED IN FOOD PRODUCTS, NO CLAIM FOR NUTRITIONAL VALUE CAN BE MADE.

****Sodium d-isoascorbate, 'Roche'**, antioxidant with virtually no vitamin C activity. A white, free-flowing crystalline material. Slightly less soluble than *l*-ascorbic compounds. When replacing *l*-ascorbic acid, 23% more should be used to obtain equal antioxidant activity and 8% more when replacing sodium *l*-ascorbate. These differences are due to the presence of both sodium and water of crystallization which are inactive. Literature on request.

d-Isoascorbic acid 'Roche'—antioxidant. Similar to sodium d-isoascorbate described above. Useful where acid reaction or absence of sodium is desirable. 10% less than sodium d-isoascorbate or 10% more than *l*-ascorbic acid (because of water crystallization) is required for equivalent antioxidant activity.

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(Reprints available)

Of Professional Interest

Chemical Food Additives[a, b]

George P. Larrick
Commissioner of Food and Drugs
and
Arnold J. Lehman, M.D.
Division of Pharmacology, Food and Drug Administration, U. S. Department of Health, Education, and Welfare, Washington, D. C.

THE PRODUCTION AND HANDLING of food has undergone a revolution within the past generation in many countries. When the first food and drugs law was being considered in the United States around 1900 some chemical additives then used in food were a hazard to the public health. Poisonous preservatives and poisonous coloring materials were being used. So the original law, enacted in 1906, declared that food would be adulterated if "it contains any added poisonous or other added deleterious ingredient which may render such article injurious to health." Under that law each food was considered alone and if it did not contain sufficient added poison to render it injurious, no action could be taken. But the total intake of poison by the consumer could not be controlled on a single product basis. If each of three items of food contained one-third of the amount of poison required to make it harmful, each would have been legal under the 1906 law, but the consumer who was unfortunate enough to eat these three items at a single meal might have been injured.

In 1938 a new law, the Federal Food, Drug, and Cosmetic Act, was passed in the United States. It attempted to remedy the defect in the earlier law by forbidding the addition of any poisonous or deleterious substance to any food except where it is required or cannot be avoided. When such substance is required or cannot be avoided, the Government shall establish, by regulation, the quantity that may be present without hazard to the public health.

This doesn't solve the problem. It forbids the addition to food of any substance known to be poisonous or deleterious, leaving uncontrolled the addition of chemicals that have not been tested enough to show whether they are poisonous.

The present law permits untested or inadequately tested chemicals to enter the food supply. If the manufacturer who chooses to use new chemicals decides that he does not care to conduct adequate toxicity tests, the burden of determining whether the new chemical should be in food then falls upon someone else. If our Government had the facilities and conducted the tests, the law still would permit untested materials to be used in food during the time they are under investigation.

Tremendous strides were made in the development of new chemicals during and following World War II. Since 1945, an amazing number of products have been suggested for possible use in foods and it is evident that better procedures for safeguarding the public health are necessary. The situation was brought to public attention in the United States in 1950, 1951, and 1952 by a Select Committee of the House of Representatives that investigated chemical additives in the food supply. This Committee decided that new legislation is necessary and recommended its enactment. Since then a number of proposed laws have been before the Congress of the United States, and at present there are several proposals before the Congress for consideration.

FOUR CRITERIA

We believe the following general requirements should be met before a new food additive is used commercially:

1. The additive should be tested thoroughly to show what effect it produces in treated food, and what residues remain from the additive, or reaction products, resulting from its use. Feeding tests on animals should show that exaggerated use of the additive produces no harmful effects, or if it does, they should show at what level of use it produces no harmful effect.

2. The results of the tests should be submitted to the Government, and the proposed use of the additive should not be allowed until the Government agrees that it is safe and so indicates by issuing an appropriate order.

3. The terms "food additive" or "chemical additive" should be defined broadly to include any substance the intended use of which results or may result, directly or indirectly, in its becoming a component of, or otherwise affecting the characteristics

[a] Delivered at the Joint Conference of The Food Law Institute of the United States and Food Group of Society of Chemical Industry, Society for Analytical Chemistry, and Association of Public Analysts, of Great Britain, in London, England, July 26, 1957, Morning Session.

[b] Published originally in the "Proceedings of the Joint Conference," *Food Drug Cosmetic Law Journal*, August 1957. Reprinted by permission.

of, any food. To avoid the necessity for elaborate testing of common chemicals, such as table salt, substances generally recognized as safe by appropriate experts could be exempted from the definition.

4. There should be adequate safeguards against arbitrary or capricious Government decisions.

Awareness of the chemical food-additive problem is increasing in many parts of the world. The very fact that this meeting is being held here in London and is being attended by representatives from a number of countries indicates the worldwide awareness of the need for new procedures to regulate the increasing use of new chemicals. This is gratifying.

WHY CHEMICAL ADDITIVES IN FOOD?

One question that we are continually meeting in the United States is: "Why is it necessary to have the new chemical additives in food?" No doubt the answer is apparent to all attending this meeting. An adequate supply of good food is necessary to a healthy nation and a good economy. The progress of nations through the centuries has been closely linked to the adequacy and the wholesomeness of their food supply. There are nations in the world today that are in serious plight, because their people exist on a dietary intake that is insufficient, or because of periodic famines.

Certainly any steps that can be taken to insure a greater supply of good food to the undernourished would improve the well-being of the world. Increased amounts of good food are frequently made possible by the safe use of chemical additives. Moreover, those countries of the world that have adequate food have in the past generation been able to obtain a greatly diversified supply of food from all parts of the world with the help of additives. Their diet is more attractive, their people are better nourished. This leads to improvement in their health as well as improvement in the economic status of the faraway countries who supply the new foodstuffs. Yet the transportation of foods from one corner of the earth to another frequently requires food additives.

The United States economy is being geared more and more to the employment of women in industry and business. Today approximately 22 million women are employed outside the home in our country and the reason that many of them can be so employed is that they have convenience foods available that can be made ready for the table quickly. Many of these convenience foods would not be possible without the chemicals that are being incorporated in the food today.

So whether our object is to reduce starvation, or to increase the variety of attractive foods, or release women from the drudgery of the kitchen, we are faced with the need for chemical additives in food handling and processing today.

This brings problems that will not be completely solved by the passage of new laws. The paper prepared by Dr. Henry Welch of the Food and Drug Administration discusses some of the problems arising from uses of antibiotics. Among other things, drug uses of the antibiotics in dairy herds in the United States have resulted in the addition of penicillin to the milk supply in quantities that could be a hazard to the health of individuals very sensitive to the drug. Another problem arises from the appearance of pesticide chemicals in the milk supply of the country. Pesticides are being employed today so that minute residues are occurring in market milk. The peculiar place that milk has in the diet of infants and many invalids requires unusual precautions to keep it free from poisonous materials. We do not have the final answer here but the matter is under active consideration.

Antibiotics have been proposed as additives to preserve food. We do not know enough yet about the effect of long-term consumption by man of significant quantities of antibiotics to sanction their widespread addition to the food supply. We have established tolerances for two antibiotics in uncooked poultry because poultry is always cooked before it is eaten and because the evidence in our possession shows that no significant residue remains in the cooked meat when the amount of antibiotic in uncooked poultry is within the tolerance level.

The coal-tar colors are causing concern. Soon after our 1938 law was passed, we established, as authorized by the law, a list of coal-tar colors which, according to the best scientific evidence then available, were absolutely harmless. In the years that followed, the science of pharmacology made great progress. When improved techniques were applied to these materials they showed that some of the colors formerly considered harmless could produce adverse effects when fed to test animals in relatively high dosage. These colors may not be harmful when used in an ordinary concentration in food but they certainly do not meet the requirement of the law that they must be "harmless." We have therefore removed two orange colors and a red color from the list eligible for certification for internal consumption and we are in the process of removing four yellows.

Some people have misinterpreted this action. They have charged that the coal-tar colors are capable of causing cancer because one of the intermediates used in the manufacture of some of the food dyes is recognized as capable of causing cancer. We do not know of any evidence that any coal-tar color now permitted in food, or any of the three colors recently removed from the list of permitted colors, is capable of causing cancer when added to man's food supply. We do not agree that chemicals made from a harmful starting material must themselves be harmful.

There is considerable public concern about cancer-producing substances. Last August in Rome, Italy, there was an international conference on cancer. Some of the comments made there to scientists and for scientists were reported by the press and publicized widely in our country. They were interpreted as indicating that many cancer-producing materials are being added to the food supply.

Some have suggested, as a result, that an additive should not be allowed in food if it produces any can-

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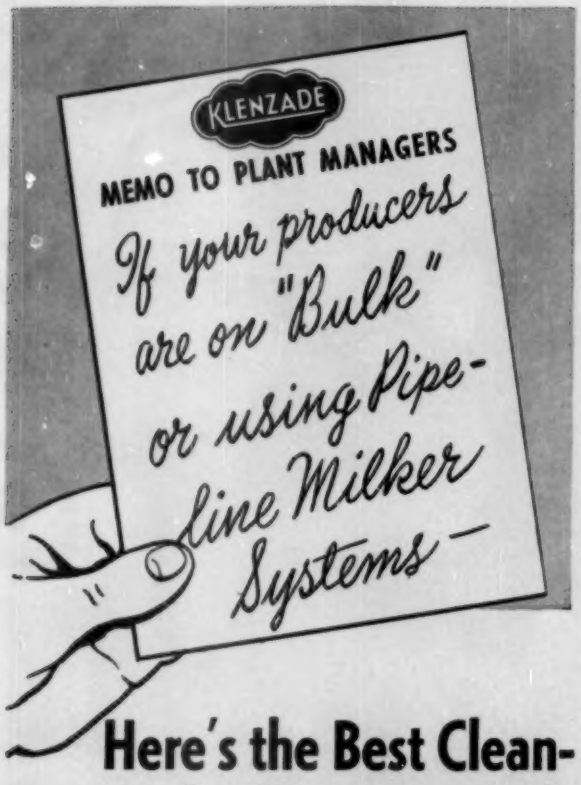

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cer in any test animal by any route of administration. Before concluding that this would be wise, we should consider its implications. Cancers can be produced in test animals by repeated injection of sugar solution into muscle tissue, or peanut oil, or cottonseed oil, or lard, or tannic acid. Probably repeated injections of some other common food chemicals will produce cancer. Do these results, obtained by procedures never employed at the dining table, mean that sugar, vegetable oils, and coffee and tea which contain tannic acid, should be taken out of the food supply?

Certainly we do not suggest the addition to food of any new chemical until reliable tests have shown beyond a reasonable doubt that it does not produce cancer or other disorders when eaten. But we think it unwise to become so possessed of a cancer phobia that we lose perspective.

HOW MUCH ANIMAL TESTING?

This raises the question, "How much animal testting is needed to show the safety of a new chemical?" It seems evident that adequate testing of a chemical that may be present in food eaten by man for a lifetime requires studies in which the material is fed to a test animal, such as the rat, for its lifetime. The test should include observations on food consumption, effects on ration digestibility and utilization, growth, absorption, excretion and tissue storage of the additive, mortality, organ weights, blood changes, blood and urine chemistry, observable changes in behavior of the animal or the functions of any organ system, effects on reproduction and lactation. Microscopic examination of the animal's tissues after death is important.

These studies should be supplemented by another feeding test on another animal, such as the dog, to detect species differences. A one-year test with the second species may suffice if the results of both tests are favorable. But no simple rigid program can be laid down that will give all the answers about the safety of each new additive in all its possible applications. An additive may be altered when incorporated in food, or it may react with constituents of the food. The changed additive or the reaction product may have different toxicity. We must remember that normal food constituents or other substances added to food may have a similar pharmacological action or may accentuate the toxic action of the additive. The influence of the additive upon the nutritionally important constituents of food and its effect on the stability of nutrients in food must be considered.

We have made no effort here to state all of the tests that may be required or to explore the difficult problem of interpreting pharmacological data and translating animal test results into permissible human use levels that have adequate safety margins. It is evident that a generous safety factor must be present when results of toxicity studies on lower animals are relied upon to determine at what level a chemical may be fed to man without hazard.

There are a number of authoritative writings on this problem. The Expert Committee on Food Additives of the Joint Foreign Agriculture Organization-World Health Organization of the United Nations

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issued its "General Principles Governing the Use of Food Additives" in December 1956. The opinions of eminent scientists of the world, as set forth in this document, are very useful. Also, we have relied on very similar principles contained in a statement "Principles and Procedures for Evaluating the Safety of Intentional Chemical Additives in Foods" issued in November 1954 by the Food Protection Committee, Food and Nutrition Board of the National Research Council, in our country.

CHEMICAL ADDITIVES: HELPFUL AND VERY NECESSARY

After a proposed chemical additive use has been shown to be safe by the best procedures available to man, we believe it should be allowed in food only if it serves a useful purpose. No available procedure will give absolute assurance that food containing an added chemical is completely safe to all men under all conditions. We can determine beyond a reasonable doubt that a proposed use is safe, but we see no need to tolerate even any very slight residual risk unless the additive does serve a useful purpose.

Chemical food additives have a very helpful and very necessary place in the world today. They are here to stay. We must learn how to use them safely. The minimum control would appear to be a procedure that requires adequate testing of a chemical before it is employed commercially in food. The test results should be submitted to the Government, and the chemical should not be used until the Government, acting for all the people, agrees that it is safe for the proposed use.

Food Additives

Our Communications and Education Problem

In continuance of the report of the discussion on chemicals in food the following contributions are offered. The panel to discuss this phase of the program consisted of Dr. Howard Spencer, Dr. Charles Frey, Prof. John J. Powers, Prof. F. J. Francis and Dr. L. E. Clifcorn, Chairman. Each participant spoke about five minutes on the subject. A digest of their comments follows:

Dr. Howard Spencer: *Does the public really understand the importance of chemicals in the production, storage, and distribution of food?*

There are many indications that there is a great deal of misunderstanding of this subject on the part of many people. This is understandable in view of the complex nature of the problem, the many factors involved, the opportunity for an honest difference of opinion between experts in this field, the aura of mystery and apprehension so often associated with the synthesis and use of chemicals, and the sensational treatment often given the subject of "chemicals in foods" in the popular press.

Food and chemical manufacturers together with university groups, research foundations, individual chemists, chemical engineers, food technologists, nutritionists, toxicologists and others intimately associated with one or more aspects of this problem have an unusual challenge—and an excellent opportunity—to tell the story of the tremendous role that chemicals are playing in this vitally important field.

Each one, in his own way and from his own viewpoint, can do much to set the record straight, to point up the accomplishments of the chemical and food industries in terms of benefits to the consumer, to explain why chemicals are essential, and to inspire public confidence in the development programs aimed at the improvement of the world's food supply.

The dissemination of information of this nature should help to establish the basic principle that the public interest is best served, not only through provision of safe-guards from possible harmful effects of chemicals that may be contained in foods, but also through provision of incentive to industry to develop new and better materials essential to the production, processing, storage, and distribution of foods.

Prof. F. J. Francis: *What are the possible approaches from the point of view of education?*

An adequate solution to the problems of public relations in connection with "food additives" requires more than we can expect from formal education as such in the near future. An intelligent appreciation of the absolute necessity of utilizing modern advances in chemical technology in order to feed our populace will only be obtained by those with an appreciation of general science. The prospects for this in our formal education channels in the near future are a little grim when we realize that 24% of our high schools teach neither chemistry nor physics.

It is the opinion of the author that general education in food additives cannot wait for the formal edtion channels to produce a sympathetic understanding in the general populace. The problem is more acute and each member of I.F.T. can help to promote this attitude. I submit that this is a good basis for professionalism and each member can make a real contribution. The facts are readily available to discredit crackpot ideas and unwarranted attacks on our professional societies and enforcement agencies. This is

[a] Presented at the Panel Discussion on Chemicals in Foods, 17th Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

One look at the huge, sprawling buildings at one of the Exchange Products plants and you know that big things are happening inside. For here *citrus* is king. Trucks pour in with fresh fruit from groves all over California and Arizona. Conveyer belts hum along in every direction. And Exchange products are shipped to nearly every part of the world.

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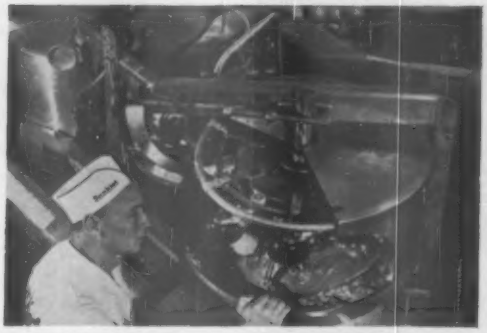
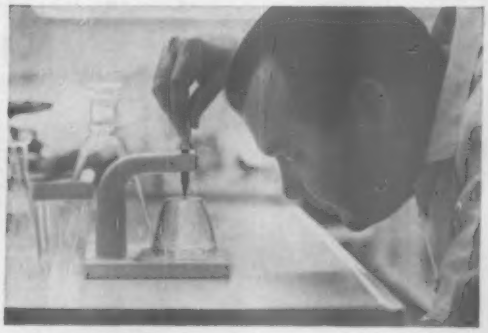


Utmost cleanliness is the watchword at Exchange Products plants. Everything has that "just washed-down" look. Every four hours, extraction equipment is completely cleaned. Every third day, the entire plant closes down for a thorough washing.



Exchange quality is assured by constant checking in extensive testing laboratories. In fact, rigid quality controls have been set up *throughout* the plant to make sure that every product measures up to Exchange quality. Sunkist produces more than 400 different citrus products.

The world's largest citrus research department is maintained by the Sunkist Growers to develop new growing methods, to improve manufacturing processes, and to perfect better products. Today, with a backlog of more than 60 years experience, Sunkist has accounted for 118 separate U.S. patents.

Just three of many Exchange products are *Exchange Preserver's Pectin*—guarantees a more uniform finished product; *Exchange Low Methoxyl Pectin*—jells *without* sugar, tasteless, controls "weeping" in pies; *Exchange Lemon Juice*—brings out natural flavor of *any* food. Superior acidulant, excellent anti-oxidant.

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only one of many approaches, but it could be effective.

PROF. JOHN J. POWERS: *What can Departments of Food Technology do?*

Food technologists in educational fields are in a particularly good position to disseminate factual information concerning the use of chemicals in foods. The first job of a Food Technology Department is to turn out well-trained, well-rounded food technologists. But a well-rounded food technologist must know more than technical facts and principles.

Food Technology Departments are not limited in their opportunities to their own majors. Future home demonstration agents, teachers of homemaking education, and others take food preservation courses in the Food Technology Department. These students, some of whom themselves will be teachers, perhaps need to learn even more than do food technologists—for their opportunities will be more limited in the future—of the tremendous benefits that have accrued to all citizens as a result of the progressiveness of the food industry, why and how chemicals are used in foods, and of the time and money industry voluntarily spends now testing chemicals prior to recommending their use in foods. Similar facts can be laid before other groups through short courses, institutes, and other educational outlets.

Education is not confined to institutions. Industry should avail itself more fully of its opportunities. House organs could be used to inform employees of the use of chemicals in foods, the necessity for their use, and the efforts the company expends to be sure they are harmless under the conditions of use. Top management has an audience which is especially potent and articulate, namely, stock-holders. Firms having an agricultural chemicals department can reach farmers and those who work with farmers; home economists with industrial firms can carry the facts to homemakers. Industry has to take the initiative just as it could, for example, take the initiative on another front by pointing out that some of the pharmacological tests recommended are so drastic that certain natural components of foods would likewise fail the test.

A preliminary report of the Ad Hoc Committee, appointed by Dr. George Garnatz to study means of liaison of the Institute of Food Technologists with Government agencies on matters pertaining to food additives, was given by Dr. Charles Frey, Chairman of the Committee. This report will be published separately at a later date.

L. E. CLIFCORN, *Chairman*, Panel on
"Our Communications and Education Problem"

New IFT Award

Call for Nominations

A new award to be administered by the IFT is the INSTITUTE OF AMERICAN POULTRY INDUSTRIES AWARD.

The Award consists of $1,000 and an engrossed plaque.

The purpose of the award is to stimulate research in the field of poultry and egg processing and marketing. To qualify a candidate, the research should be such that it reflects increased consumption of poultry and egg products.

NOMINATIONS

Nominations may be made by any member of IFT or any Regional Section of the Institute and by any member of the Institute of American Poultry Industries. Nominations shall be in letter form giving a biographical sketch and indicating the contributions that qualify the nominee for the award and shall be limited to two, single-spaced, typewritten sheets. The nominee must be a person under 39 years of age on December 31, 1958.

Send nominations to:

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Chicago 9, Illinois

Nicholas Appert Award

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The Nicholas Appert Medal and an honorarium of $1000, is awarded annually to a person for "pre-eminence in and contributions to the field of Food Technology."

Nominations for the Award may be made by any member of the Institute of Food Technologists. They must be in letter form giving a biographical sketch of the nominee and indicate the contributions that qualify him or her for the Award. Nominating letters shall be limited to two, single-spaced, typewritten sheets.

Nominations must reach the Chairman of the Jury on or before December 15, 1957.

CLARENCE K. WIESMAN
Chairman, Nicholas Appert Award Jury
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Food Research Department
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Chicago 9, Illinois

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Review of Advances Reported at the Poultry Science Association Meeting

W. J. Stadelman
Purdue University, Lafayette, Ind.

POULTRY SCIENCE ASSOCIATION held its 46th annual meeting at the University of Missouri, Columbia, August 6 to 9, 1957. The Scientific program included 230 papers presented in the fields of product technology marketing, poultry nutrition, genetics, environmnt, physiology, pathology and teaching methods. Thirty-six of the papers were on subjects of food technology as related to poultry meat and eggs. Attendance at the meetings exceeded 800 members and professional guests with representatives from most of the States and Canadian Provinces as well as several foreign countries.

DIET

A subject relatively new at Poultry Science Association meetings was the effects of the diet fed poultry on carcass composition and flavor. Six experiment stations reported results on this subject. Rand and coworkers of the University of Illinois found that fat content of the carcass was more closely linked to protein level of the diet than to energy level or fat content of the ration. The higher the protein in the diet, the lower the fat content of the carcass. High levels of dietary protein tended to decrease the portion of carcass fat derived from dietary fat. Similar results were reported by Spring and Wilkinson of Louisiana State University. They found that with 25 or 28% dietary protein increased dietary energy did not increase chicken body fat but that with only 22% protein diets there was an increase in body fat with an increase in dietary energy. Essentially the same results were reported by Scott and coworker of Cornell University working with ducklings.

According to Leong and others of the University of Wisconsin, dietary fat did not affect flavor of chicken. Fry *et al.* of Purdue University reported that hormonization increased flavor of poultry meat under certain conditions of measuring. Age significantly influenced flavor, with fryers and roasters being more flavorful than the small one-pound (6-week old) chicken. For exotic flavors in poultry meat Newman and Schaible of Michigan State University reported on the inclusion of spices in the poultry ration. Garlic in the feed had greatest effect on flavor of cooked meat of any of the materials tested.

Several papers presented indicated that quality of dressed poultry can be improved by using synthetic estrogens in the feed or as injections in paste or pellet form. Wesley of Purdue reported an improvement in tenderness and juiciness of 14-week old boilers. Adams of Wisconsin reported an improvement in finish as measured by subcutaneous fat deposition in turkeys. Mountney and others of Texas A & M and Miner and others of the U. S. Department of Agriculture also reported favorable results by using diethylstilbestrol for finishing turkeys.

FREEZING

Another subject with reports from several experiment stations was freezing of turkeys. Klose *et al.* (U. S. Department of Agriculture) discussed the quality deterioration of frozen turkeys as a function of time, temperature, and packaging materials. The main disadvantage of a fluctuating temperature was moisture loss and frost accumulation on the interior of the package. Two reports from Purdue, one by Mitchell and the other by Marion, reported on the use of immersion freezing techniques on poultry meat. Mitchell tested liquid temperature, rate of liquid flow, and viscosity of the freezing media as important factors in determining rate of freezing. Bird size, within limits, did not significantly affect

spice
RESEARCH NEWS

Four-Year Study Pinpoints Antioxidant Values of Spices

Research conducted at the Hormel Institute (University of Minnesota) has established the antioxidant activity of 32 spices in several types of fat-containing foods.

A total of 78 samples of the spices were used in tests run on lard, baked pie crust, a simple oil-in-water emulsion, mayonnaise, French dressing and ground pork which was stored at both 23° and 5° F.

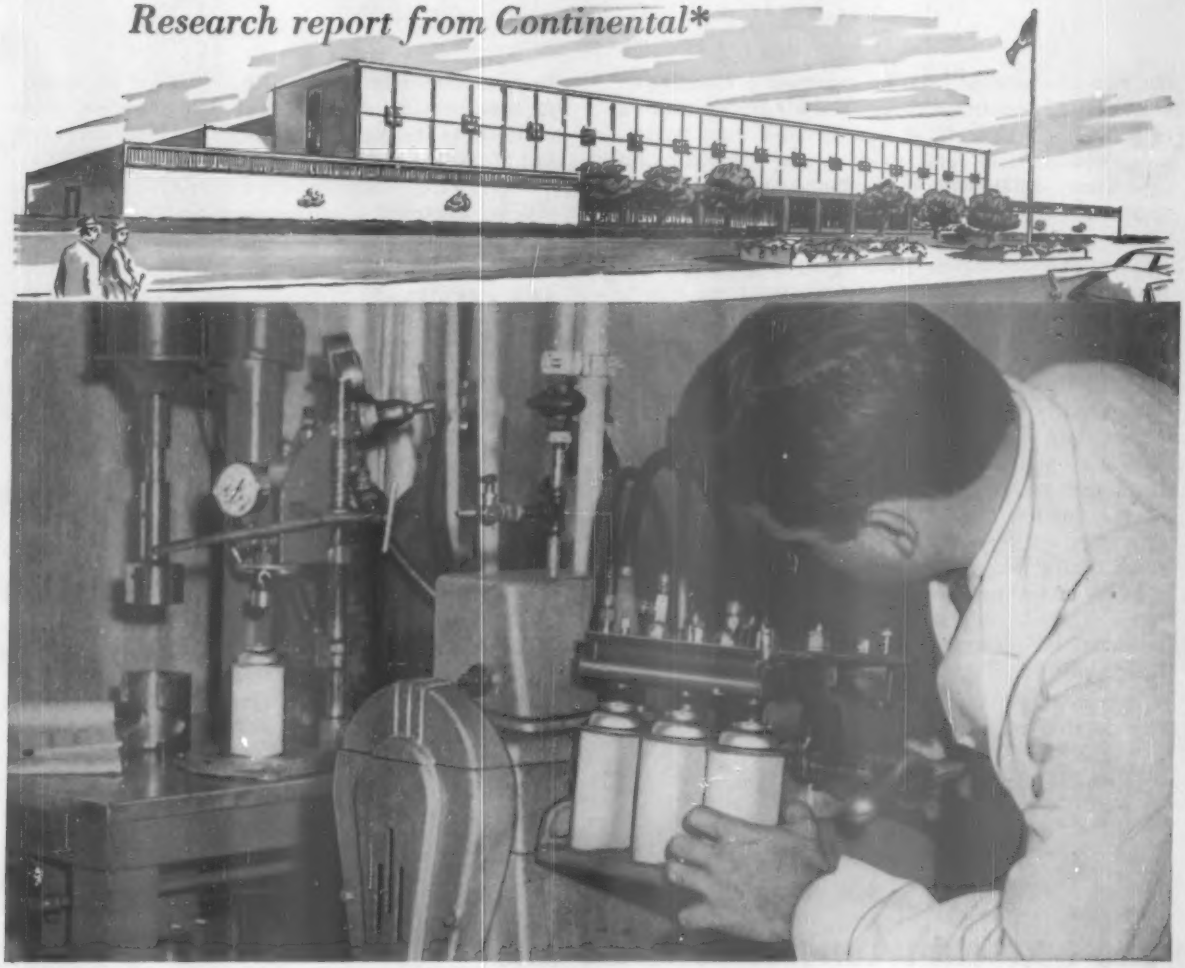
Highlights: Sage and rosemary were found to be outstanding antioxidants in lard, each extending stability several times. Soluble fractions of the spices were found in the main to have less antioxidant power in lard than the ground spices. Oregano, rosemary, thyme and sage lengthened storage life of pie crust appreciably. Cloves, turmeric, allspice, mace and rosemary proved excellent antioxidants in the oil-in-water emulsion, as were allspice, cloves, rosemary and sage in ground pork. In mayonnaise, oregano had the highest antioxidant index, followed by cloves, rosemary, sage and thyme.

° ° ° °

FURTHER DETAILS . . . on this Antioxidant Research Project are available from the Information Bureau, American Spice Trade Association, 350 Fifth Avenue, New York 1, New York.

American Spice Trade Association

*Research report from Continental**



RESEARCH AT CONTINENTAL BREAKS THE "PRESSURIZED FOOD" BARRIER

Look for a new era in pressurized packaging, thanks to Continental research. Previously, the only marketable pressurized foodstuffs were foam products like whipped cream. Now Continental engineers have pressure packaged such foodstuffs as salad dressings, catsup, mustard, meat tenderizers and sauces, table syrups, cake toppings, and chocolate syrup.

Designing pressurized containers for these foodstuffs seemed a formidable task. Non-toxic compressed gases did not give a spray or stream pattern with known types of dispensing and left as much as 20% product residue in the container.

To overcome these obstacles, Continental engineers began sustained experimentation with numerous gas mixtures, with specially designed valve openings and actuators, and with many different food products. Pressurized food containers developed by this research dispense water-base or oil-base food products by means of non-toxic propellants in a spray or stream pattern with a minimum of aeration and product residue.

This is one more example of successful Continental research on a basic container problem. If you have a packaging or processing problem, Continental experts can help you solve it. Why not call your nearest Continental representative.

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the rate of freezing. Marion reported a comparison of quality of immersion frozen and air frozen turkeys and chickens. Criteria of quality used were tenderness, cooking loss, and drip during thawing. No significant differences were found between birds frozen at +10° F. by immersion freezing and others frozen at −20° F. in an air freezer. Eklund and coworkers at Washington State College report a reduction in freezing time of about 50% by using immersion freezing instead of air blast.

QUALITY

A report from the University of Nebraska by Rhodes and Feeney compared the stability and biochemistry of chicken, turkey, duck, and goose eggs. Duck and goose eggs deteriorate, with respect to albumen quality, at a much slower rate than chicken or turkey eggs. Garibaldi and Stokes, U. S. Department of Agriculture, reported further on the effectiveness of the egg shell membranes as bacterial barriers. They found that the ability of organisms to penetrate the shell membrane is closely associated with their ability to digest extracellular proteins.

A report by Fisher and Leveille of Rutgers University pointed out that it is possible to greatly increase the unsaturated fatty acid content of eggs by supplying unsaturated fats in the diet of laying hens. Such additions to the diet did not affect the cholesterol content of the egg yolk.

There were numerous other extremely interesting papers. Abstracts of all papers were published in the September issue of Poultry Science.

NEW OFFICERS

At the annual business meeting of the Association Dr. H. R. Bird of the University of Wisconsin was elected president, Dr. J. H. Bruckner of Cornell, first vice-president, and G. E. Bearse of Western Washington Experiment Station, second vice-president. C. B. Ryan of Texas A & M was reelected as secretary-treasurer. Meeting places for the next three years were announced as 1958, Cornell University (50th Anniversary); 1959, Iowa State College; and 1960, University of California at Davis.

An action of the Association of interest to members of IFT was acceptance of the Institute of American Poultry Industries research award to be rotated on a biennial basis with the Institute of Food Technologists. Information concerning this action appeared in the October issue of FOOD TECHNOLOGY.

The Sixteenth Congress of Pure and Applied Chemistry

Paris, France, July 18-24, 1957

Frank A. Lee

New York State Agricultural Sttaion, Geneva, New York

THE INTERNATIONAL CONGRESS was a special occasion because it was connected also with the celebration of the 100th anniversary of the French Chemical Society. All the events took place in the setting of the University of Paris, at the Sorbonne.

The main lectures were in either French, English, or German. Running translations in the two languages, other than that used by the speaker, were projected on screens on each side of the speaker's stand, simultaneously with the delivery of the talk. Three main lectures were delivered each day except Saturday, on which day two lectures were given.

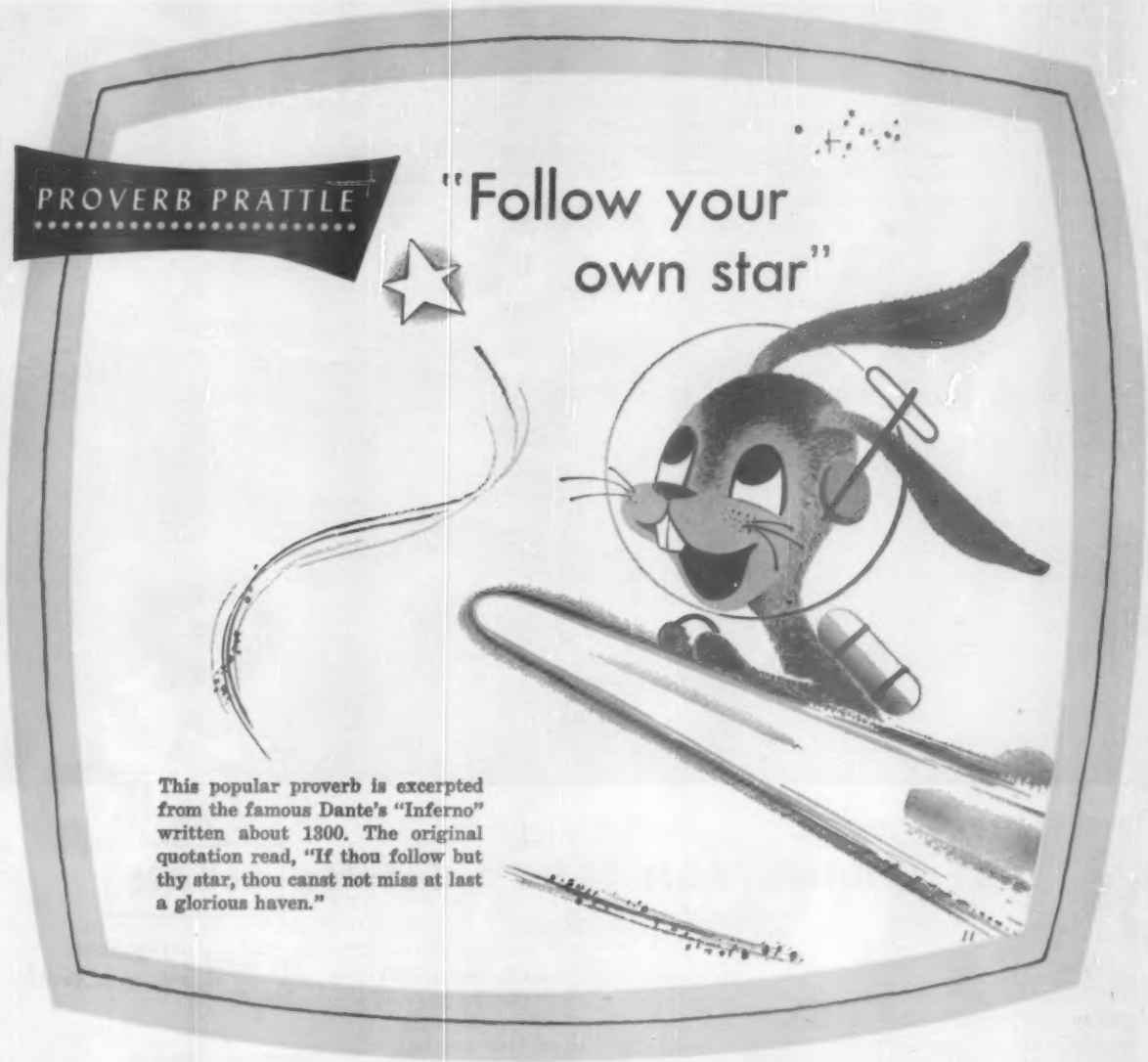
The subjects of the main lectures each day were usually varied. For example, on Tuesday, July 23rd, the subjects of the three main lectures were:

9:00 a.m.	Chemistry of natural tropolones and allied compounds. Prof. T. Nozoe.
11:15 a.m.	The study of fast reactions by mass spectrometry. Prof. C. Ouellet.
4:30 p.m.	High temperature chemistry. A pioneering field. Prof. L. Brewer.

The Congress was divided into three main divisions for the presentation of research papers, as follows.

Division I. Physical Chemistry.

a. Physico-chemical aspects of radioactive elements.
b. Combustion of gaseous mixtures.
c. Water in chemical compounds.
d. Diffusion in liquids and gels: reactions and structures.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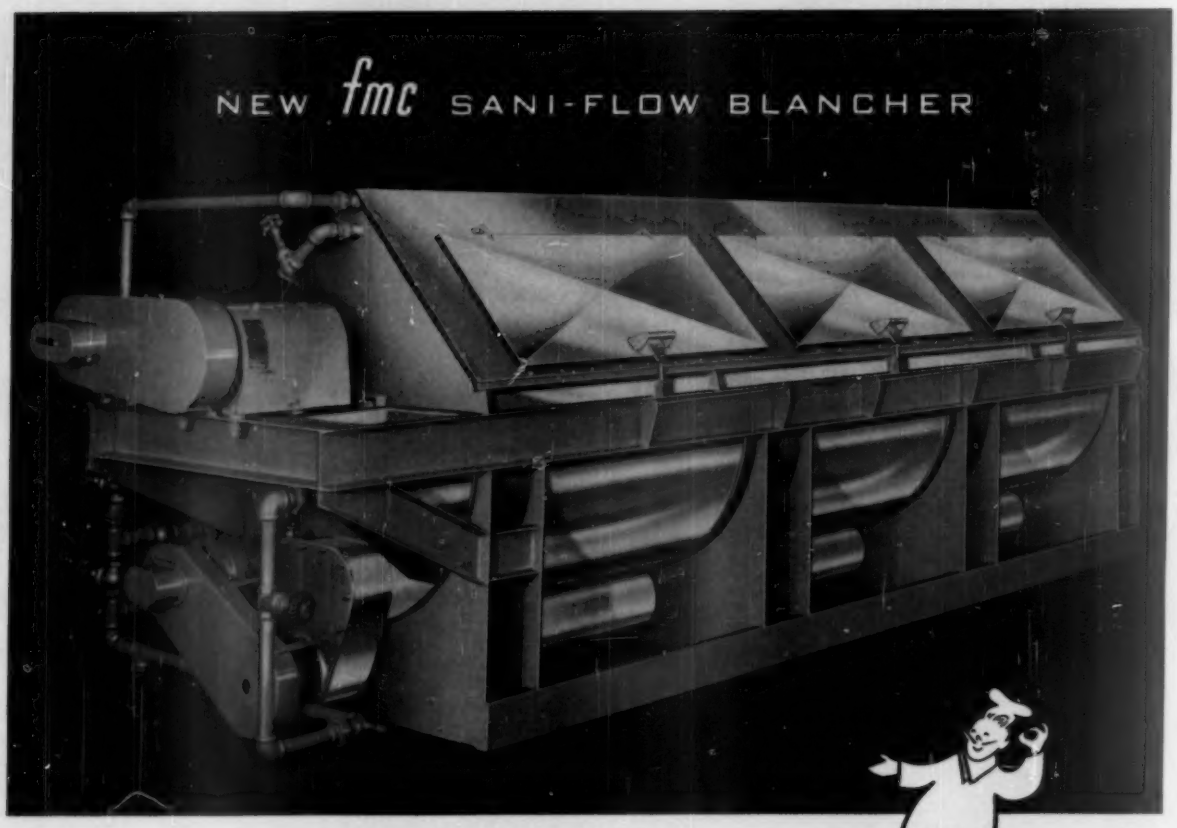

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A look at FMC's new Sani-Flow Blancher and its basic construction features shows why this machine is so easy to keep clean and absolutely sanitary.

In design it departs from past conventional standards quite radically by housing a perforated spiral screw within a round bottom shell and hood combination.

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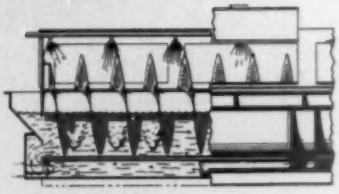

This is no ordinary screw conveyor. It is carefully fabricated and machined to maintain an extremely close tolerance with the shell. Channeling is avoided. Screw acts as timing device for controlling the through-put rate of the product.

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c. Selective reactions and orientation phenomena; stereochemistry.
d. Structure and synthesis of natural compounds (except macro-molecular substances).

In addition to these divisions, other papers were classed as *various papers*—i.e., papers which had no bearing on the subjects mentioned above were grouped under this special subject. Research papers were delivered in the language chosen by the speaker, usually English, French, or German. They were not translated.

From the Food Scientist's point of view, the most interesting papers appeared in Division III, Organic Chemistry, under the fourth part, structure and synthesis of natural compounds. A number of these papers were related, directly or indirectly, to food materials.

Some of the work reported on the components of plants concerned the alkaloids. The pharmaceutical manufacturers are particularly interested in emetine and its derivatives, and several papers dealt with the synthesis of this particular alkaloid.

A number of papers were concerned with the synthesis of peptides.

Papers in the chemistry of natural product groups were on such diverse subjects as sugars, flavones, hormones, carotenoids, tocopherols, and terpenes. The large number of papers devoted to the subject of the chemistry of natural products is an indication of the interest in this important section of organic chemistry today.

A NEW IDEA IN PROGRAM MANAGEMENT

Of particular interest to the IFT member were two electric lights on the speaker's table. These lights, yellow and red, were controlled by the chairman. Three minutes before the speaker's time was up, the yellow light was turned on. When the speaker's time had expired, the yellow light was turned off, and the red light was illuminated. In this way, it was much easier to hold the sessions on schedule. This system might well be adopted by the IFT for use at the annual meetings.

The banquet for the Centenary of the Société Chimique de France and the XVIth International Congress of Pure and Applied Chemistry was held in the "Orangerie" at Versailles on Monday, July 22. Chairman was Monsieur le Ministre des Affaires Étrangères. After the banquet, the fountains were operated with illumination and a Night Festival was given in front of the palace. The festival was the story of Chateau de Versailles, the residence of the French Kings, built during the reign of Louis XIV. It was a most interesting and unusual spectacle.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

December 26–31	American Association for the Advancement of Science, Indianapolis, Indiana
January 27–30	Plant Maintenance and Engineering Show, International Amphitheater, Chicago, Illinois
February 25–26	Sixth Annual National Dairy Engineering Conference, Kellogg Center, Michigan State University. Sponsored by the Agricultural Engineering and Dairy Departments
March 2–9	International Trade Fair of Packaging Machines, Confectionery Machines, and Packaging Materials, Düsseldorf, Germany
April 7–11	The American Association of Cereal Chemists, Netherland-Hilton Hotel, Cincinnati, Ohio
May 25–29 1958	**Eighteenth Annual Meeting of the Institute of Food Technologists, Palmer House, Chicago, Illinois**
May 17–29 1959	Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadelphia, Pennsylvania
May 15–19 1960	Twentieth Annual Meeting of the Institute of Food Technologists, Civic Auditorium and Hotel Whitcomb, San Francisco, Calif.
May 7–11 1961	Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York City
June 17–20 1962	Twenty-second Annual Meeting of the Institute of Food Technologists, American Hotel, Miami Beach, Florida

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

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The World I Lived In

Emil M. Mrak
University of California
Davis, California

SINCE 1942 when the Appert Award was first initiated by the Chicago Section of the Institute of Food Technologists, a number of scholarly presentations have been made by recipients of the award. Some were quite specific as to subject matter, whereas others were more philosophical. The present address will relate to an area of teaching and research that has yielded a wealth of satisfaction to this speaker. Until the time Professor Cruess passed on to me a university desk set, with all its administrative duties and headaches, I spent considerable time in an area that might be defined as the biology of yeast. These organisms have been thrilling to work with because they are small and have a short period of generation; yet they are sufficiently large to permit one to observe with relative ease their intimate characteristics and activities. I should like to share with you on this day, some of the thrills and satisfaction brought into my life by working with these organisms. I would like to tell you about some of the interesting aspects of their habits in a manner that I hope will be interesting to everyone here. This field of inquiry is a challenge—but also one that is most pleasing to pursue.

In discussing the biology of yeast today, little or no reference will be made to basic physiology, taxonomy, genetics, or even the use of yeast in the food and industrial fermentation industries. Instead, I should like to devote the time allotted me to a discussion of what yeasts are, how they reproduce, where and with whom they live, and some of the things they can do to certain foods.

Originally yeasts were considered "things" that produced alcohol. We can go back to some of the earliest literature and find reference to the pleasures yeasts brought man by the production of alcoholic beverages. At the time of Appert relatively little was known about yeasts. In 1810 Desmazieres wrote a series of papers pointing out with great enthusiam that yeasts were little organisms that required great patience for observation. In reading his early literature one is amused by the detailed procedures he used in order to obtain growth. A certain type of soup plate was filled with a certain type of liquid and allowed to remain open in a room for at least 3 weeks. Then Desmazieres observed a series of peculiar organisms, presumably one forming after the other. I have copied one of Desmazieres' early drawings to show what he believed yeasts to be. (Fig. 1).

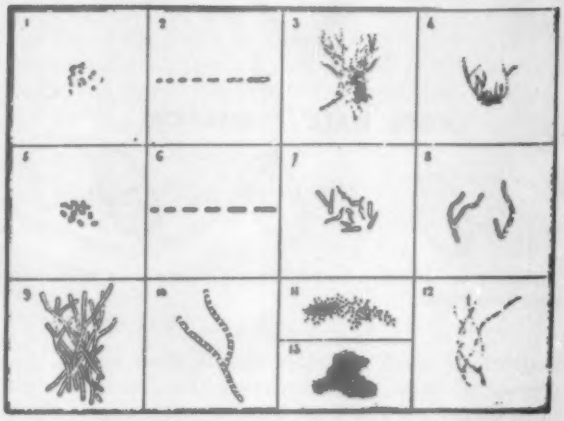


Figure 1. Yeasts as Desmazieres saw them in 1810. He believed all the forms illustrated merely represented different stages in the life of a particular yeast.

THE PROBLEM OF DEFINITION

Although we have learned a great deal about yeasts since the days of Desmazieres and Appert, we still find it most difficult to define them. Perhaps one reason for this is that we know a great deal more about them, and realize that taxonomic boundaries are literally impossible. Webster defines yeast as "a substance consisting of the aggregated cells of certain minute sac fungi, and appearing as a surface froth or as a thick sediment in fruit juices, malt worts, and other saccharine liquids, in which it induces alcoholic fermentation through the agency of an enzyme". Webster, apparently, had the beer or alcoholic beverage point of view and followed a then popular school of thought.

Because of the difficulty of delimiting the yeasts proper from closely related fungi, the writer and Dr. Phaff have defined yeasts and yeast-like organisms on a much broader basis. Because there are many yeasts with widely different characteristics, it has been necessary to establish a broad definition. This definition includes those organisms that form sexual spores by "free cell" formation, and in a "naked fruiting body". Now let us see what this means. A sexual spore is one that forms through a reduction division of the nucleus immediately after conjugation of two (haploid) cells or after numerous generations of diploid cells have formed following the act of conjugation. By free cell formation we mean that the spores are cut out freely in the protoplasm and not by the formation of cross walls from one side of the fruiting body to the other (Fig 2). By the naked fruiting body we mean, that the sacs (or asci) containing sexual spores are not enclosed in a special structure (Fig 3). This definition, however, does not take into consideration all yeasts. Some of them have lost their ability to form sexual spores, although they may look

[a] The Appert Award address, delivered at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

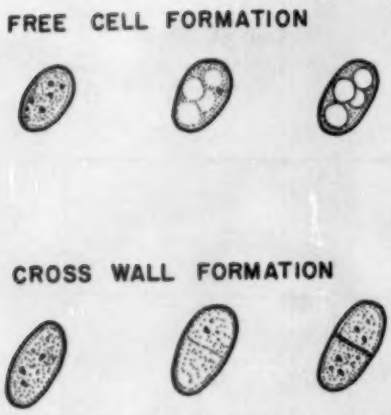
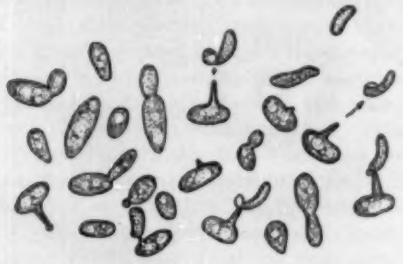


Figure 2. A comparison of free cell formation with cross wall formation.

and behave much like those that do form spores. Inclusion of these, then, broadens the definition. We must go further and include other organisms that look like yeast but form exterior spores on the end of "little stems" or as we would call them sterigmata (Fig 4). These spores are formed on the tips of the sterigmata from which they are shot off. Interestingly enough some of these yeasts are called *Sporobolomyces*. The name *Sporobolomyces* can be disected into three parts: "sporo" meaning spore, "bolo" meaning throw, and "myces" referring to a fungus. It is, therefore, a fungus (or yeast) that throws its spores.

The average person is inclined to believe that yeasts are organisms that always reproduce asexually by forming buds. This is not the case. Certain ones form cross walls, and strangely enough, others undergo an intermediate process that we have termed "bud fission" (Fig. 5). Yeasts are normally considered as single celled organisms; however, there are some in which a large number of cells remain attached (after budding) to form a "pseudomycelium". In other cases true hyphae result from the formation of cross walls. (Fig. 6).

It is apparent that the term yeast includes a large number of organisms with widely different characteristics. The Dutch workers accepted 29 genera, whereas Phaff and I are inclined to include another 12 to 15 genera on the basis of our broader and more in-



Sporobolomyces roseus

Figure 4. Sporobolomyces (note the sterigmata, and attached and detached spores).

clusive definition of yeast. There are between 200 and 400 species but the exact number depends on whether the taxonomist is a "species splitter" or "species lumper".

Slant cultures of yeast may be smooth or rough and show considerable beauty. They may vary great-

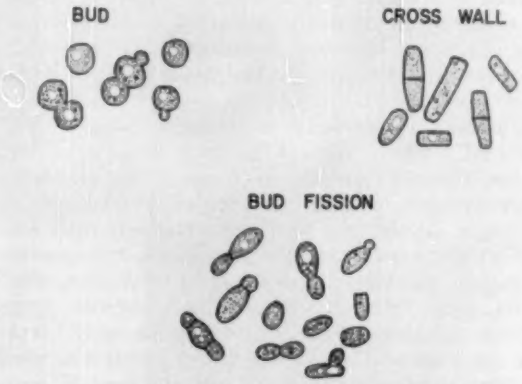


Figure 5. Examples of buds, cross wall and bud fisssion.

ly in color, depending upon the particular organism. Most yeast are cream colored, tan, or gray but more spectacular colors include yellow, pink, red, greenish and even black.

Shapes. Frequently we see illustrations defining the characteristic shapes of yeast cells (Fig. 7). These can be very useful if used with the understanding that all cells of a particular organism do not necessarily look like those illustrated. In youth, yeast cells are usually small and spherical but, as they grow older and larger, they assume the char-

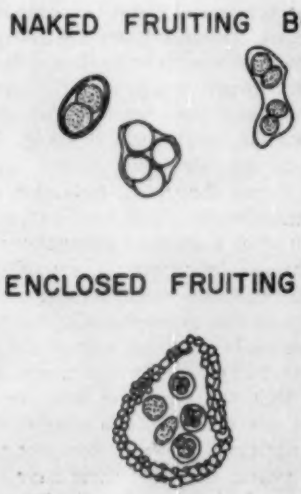


Figure 3. Example of naked and enclosed fruiting bodies.

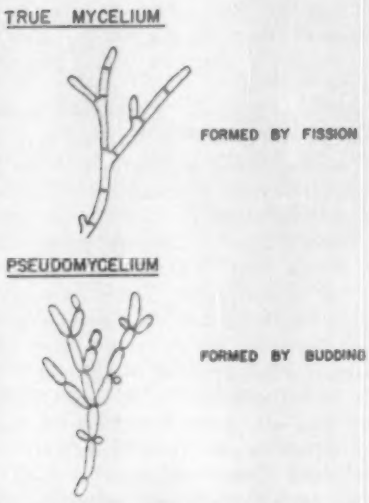


Figure 6. Pseudomycelium and true mycelium.

acteristic forms set forth by the illustrators. When they grow old, just as in the case of people, their forms change. In some cases, they tend to shrivel and become granulated and in other cases they become elongate and almost snakelike (Fig. 8). In examining cells, therefore, it is necessary to observe them in 3- or 4-day-old cultures and again after a more extended period of growth.

There are statements in the literature to the effect that yeasts have been isolated from bottles of wine stored over 100 years, but not from samples 150 years old.

Sexual spores vary greatly in shape (Fig. 9). The point of conjugation in bakers' and brewers' yeast is very deceptive and difficult to see. The average cell may be seen to form one to 4 spores, without any evidence of conjugation preceding spore formation. However, fusion takes place shortly after spore germination, between the very small buds or cells forming at that time. The fused cells then form large vegetative cells which reproduce by budding for many generations before again forming ascospores (Fig 10).

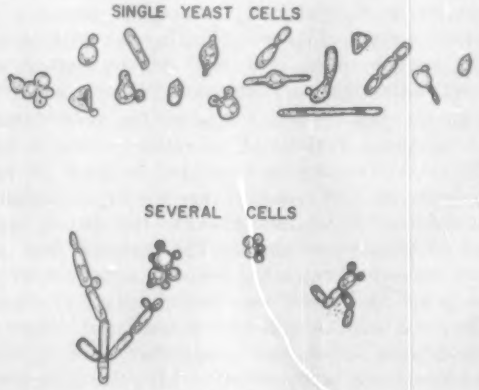


Figure 7. Types of yeast cells.

These large cells are the ones that are active in fermentation and are easily seen with the microscope. On the other hand, the cells of *Debaryomyces* (which occur frequently in the surface films on brine tanks) fuse to form a dumbbell type of conjugation product just before spore formation. One or two rough spores then develop in one of the cells. Germinating spores produce cells which ordinarily develop many generations before fusing. In some cases, however, dumbbells may form very shortly after spores germinate (Fig. 11).

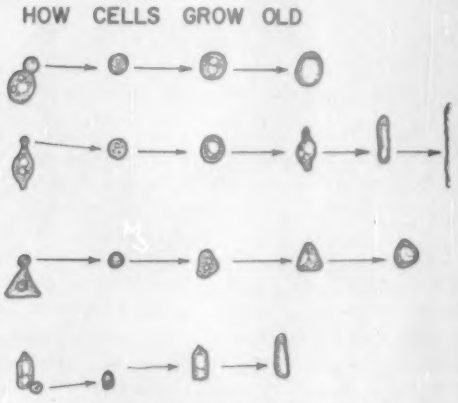


Figure 8. How yeast cells grow old.

Another interesting type of life cycle is that of *Saccharomycodes*. In this organism the large cell that is active in fermentation forms spores under appropriate conditions. Upon germination, however, the spores within the cell fuse in pairs. This always occurs prior to liberation of the spores from the cell (Fig. 12). Should, by chance, a spore escape without fusion, it is doomed to a life of asexuality and will not fuse or form spores. Here, then, is one method whereby a non-sporulating strain of yeast may develop. The cells would look different and the physiological properties might be different.

Such procedures in the life cycles of yeasts are important to the yeasts because they enable maintenance of hybrid vigor.

HABITATS

Now we come to what I consider the most interesting part of this presentation. Where do the yeasts

Figure 9. Shapes of asco spores.

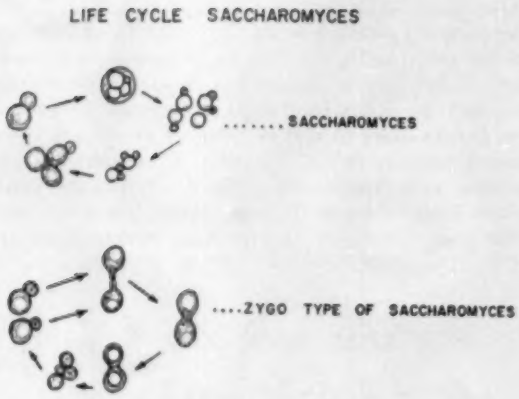


Figure 10. Life cycles of Saccharomyces.

live and with whom do they live? Yeast are more widely distributed than most people believe. Although not as widely distributed as bacteria, they do occur in a great variety of habitats which are ordinarily more specific than those of many bacteria. Yeast are plants and, just as in the case of plants, the habitats are somewhat restricted. The acid tolerance range for yeasts varies, depending upon the organism, from pH 2.2 to 8 and likewise the temperature from 0 to 47° C. Some yeasts will not grow above 17° C. and others not below 15° C.

Let us look at a few examples in nature. Naturally yeasts are associated with sugary substances, the most obvious of which are fruits. It is rather interesting, however, that the number and type found on fruits vary with the time of year and maturity of the fruit. As the fruit matures the numbers increase and in some cases the types changes. Likewise, if we investigate the soils we find a definite variation with season. The largest number and variety occur during the flowering and fruiting season and the smallest in winter. There may be some variation with the type of soil and most certainly with the altitude. Hansen observed that the higher one goes into the mountains the fewer yeast he would expect to find in the soil.

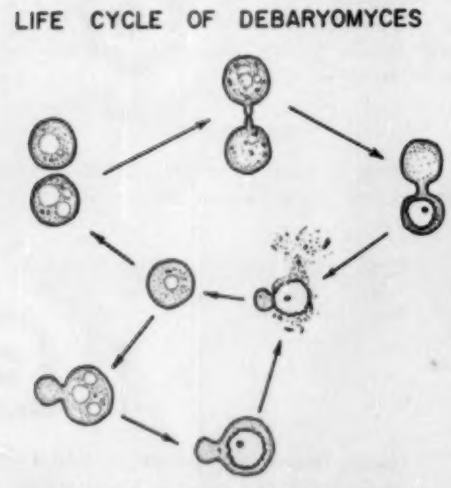


Figure 11. Life cycle of Debaryomyces.

In the nectar of flowers. Surely we would expect to find yeast in the nectar of flowers. In some cases, there have been striking adaptations to the peculiarities of a life in flowers. For example, *Canida reukaufii* is a fascinating organism that can be found in the nectar of certain types of plants, particularly *Teucrem fruticans*, a mint. These yeasts have a peculiar airplane type of morphology and, partially because of this, can stick to the hairy tongues of bees and be transmitted from one plant to the other (Fig. 13). This is highly advantageous to the yeast from the standpoint of distribution. They multiply in the flowers and then are transferred from one to the other by bees and other insects. Other yeasts are also found in the nectars of flowers and some of these are quite tolerant to rather high concentrations of sugar.

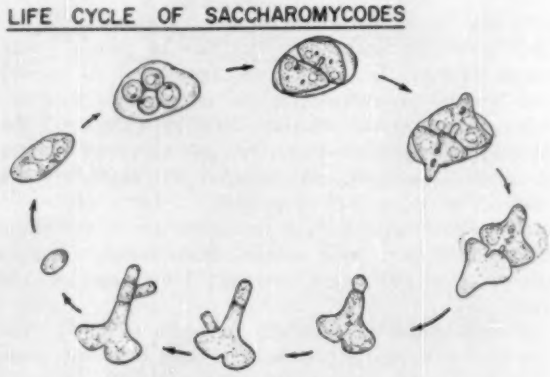


Figure 12. Life cycle of Saccharomycodes.

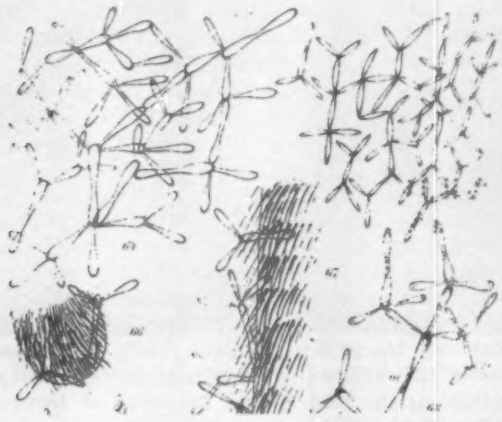
Phaff and I have been intrigued by the tremendous number of bees visiting *Cotoneaster* flowers near our building. These flowers always contain a large number of yeasts. On the other hand, other flowers just a few feet away seem to be much less attractive to bees. One may wonder of what interest is this to Food Technologists. In this case it could be of great interest, particularly if *Cotoneaster* plants were located near a packing plant during the packing season. The packer could very well be confronted with a yeast contamination problem as well as a bee problem.

In the sap of trees. One of the most intriguing sources of a variety of primitive yeasts is the sap of trees. Frequently trees are injured or cracked because of cold during the winter or because of mechanical injury, and then, in the spring, sap runs out of these open places. The material that gathers and concentrates in the injured areas literally supports a "zoo" and "botanical garden" of organisms. The total mass is called a "slime flux". Slime fluxes, which may exude sap year after year, are always referred to as a reservoir of interesting and strange yeasts. Our students studying the biology of yeasts

are always encouraged to make isolations from these interesting sources.

In rotting forest wood. Rotting forest wood is frequently a good source of yeast. Here we have fungi that are decomposing cellulose and other polysaccharides with the liberation of nitrogenous and carbohydrate substances easily utilized by yeast. Yeast, therefore, tend to live with wood destroying fungi. However, the growth of the yeast seems to attract certain types of beetles which use the yeast as a source of food. This is an indication of the type of relationship that may exist between yeasts, higher plants, and insects.

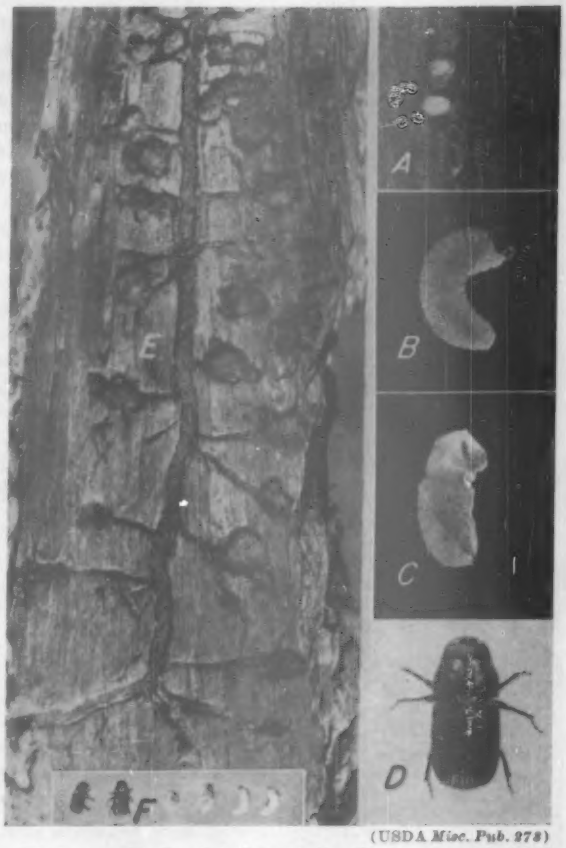
As stated above, the relation of yeast to insects is an important one. We may wonder how yeasts get into slime fluxes, rotting logs, or other places. Naturally, one method of transfer is by insects. In many cases, yeasts serve as a source of food for insects which dwell in nature where yeasts are available to



(Jahrb. f. wiss. Botanik. Bd. 66)

Figure 13. Candida reukaufii.

them. Because of this, we have made some intensive studies in the area of yeast insect ecology. One of the studies has been concerned with yeast in and on the bark beetles which attack pine trees. We have found, however, that it is not a simple matter to obtain the bark beetles in the forest and study yeast in the intestinal tracts in a laboratory many miles away. We could isolate the bark beetles in the forest and take them to the laboratory and get a satisfactory picture of the *surface* yeast flora. It is not possible, however, to study the *intestinal* flora of bark beetles unless special procedures are used. Naturally, if bark beetles eat the yeast they digest them. Therefore, if bark beetles are collected in the mountains and brought in to the laboratory, the yeasts are usually digested before we can streak out the gut. In the case of the bark beetle, therefore, it has been necessary to bring sections of logs to the laboratory so the beetles and their larvae may eat and live happily with full stomachs until it is time to extract and plate out the guts (Fig. 14). This is a rather



(USDA *Misc. Pub. 278*)

Figure 14. Wood attached by beetle. Yeasts can be isolated from these areas.

simple procedure, but it was developed as a result of many unhappy experiences. Suffice it to say that a very characteristic yeast flora was observed.

DROSOPHILA AND THE YEASTS

Even more fascinating has been our experience with *Drosophila,* the fruit fly. For many years it has been the practice of geneticists to grow fruit flies in the laboratory on a food composed of bananas, a mixture of bananas and yeast, or just yeast. Fruit flies are attracted by odors produced by certain yeasts and ingest them as food. Population geneticists have been interested in determining the possible relationship between the occurrence of successive populations in nature and the availability of yeast they use as food. Since these successive populations occur in isolated areas the *Drosophila* flies and yeasts involved are "wild" rather than "domesticated" types. The yeasts eaten by the flies, therefore, are distinctly different from those ordinarily encountered in inhabited areas, camps, or garbage cans. The ecological implications were intriguing and so we became interested in the food habits of *Drosophila* flies in nature.

We started collecting fruit flies in remote areas of the mountains of southern California. These were sent to the laboratory in northern California where

the intestinal tracts were removed and studied for yeast content and type. The flirst trials were failures, for the crops and stomachs were empty. Just as in the case of the pine bark beetles, the *Drosophila* flies digested their food quite rapidly and when they reached the laboratory the digestive tracts were empty. It became necessary, therefore, to study factors influencing the rate of digestion. One of the most important factors was found to be temperature. This is well illustrated in Fig. 15. It was possible, therefore, to collect flies, refrigerate immediately and ship them under such conditions to a distant laboratory with a minimum of yeast destruction resulting from digestion. The presence of undigested cell walls could be determined easily by staining with methylene blue. It seems that during the digestion process the contents of the yeast cell are extracted without deformation of the cell wall. Fly pellets consist of clumps of empty cells which stain well with methylene blue.

SURVIVAL OF YEASTS IN D. PSEUDOOBSCURA STORED FOR VARIOUS PERIODS OF TIME AT DIFFERENT TEMPERATURES.

Storage time after feeding	Average number of cells per alimentary tract			
	Room Temperature	15°C	5°C	0°C
Immediately after feeding	150,000	150,000	150,000	150,000
24 hours	65	500	3,200	93,000
48 hours	0	160	1,500	62,000

Figure 15. Rates of digestion of yeast by Drosophila at different temperatures.

Extensive studies on yeast florae occurring in flies and possible habitats of flies failed to reveal any relationship between fly population type and yeast flora. It was observed that some species of *Drosophila* visited slime fluxes for the purpose of depositing eggs but not to feed on the yeast growing there. Larvae, on the other hand, could do very well in the slime fluxes and could live on the particular type of yeast flora occurring there. The flies themselves, however, apparently fed on different types of yeast and in different places. This proved to be an extremely interesting observation because here we have the same organism using two distinctly different habitats and sources of yeast as food in nature. For example, the slime fluxes studied contained species of the yeast genera *Pichia, Debaryomyces,* and *Hansenula.* I can't refrain from stating that one species was *Hansenula mrakii.* On the other hand, yeasts found in adult flies were species of "apiculates" *(Hanseniaspora* and *Kloeckera), Saccharomyces* (not bakers' or brewers' yeast) and *Candida.*

ACCEPTANCE TESTS WITH DROSOPHILA AS SUBJECTS

It was also observed that flies have a preference for certain types of yeasts. Accordingly "fly acceptance tests" were conducted in the mountains.

The flies are trapped by merely exposing sterile bait in large cans (approximately one gallon) in various locations of a given area. Flies go to the bait, which consists of bananas fermented by yeast followed by sterilization with ethylene oxide. This procedure permits fruit and yeast odors to permeate the surrounding air and attract the flies. Flies feeding on the bait in the cans are eventually collected in a net placed over the cans. While attempting to escape, the flies enter the net.

In conducting the attractivity (acceptance) tests, a number of pure yeast cultures were grown in cans as indicated above and exposed to the flies at various points in isolated areas. Cans with different yeast were located and relocated from point to point according to a statistical plan. Invariably, apiculate yeasts were found to have the highest attractivity (Fig 16). The rather amazing part of such tests was the observation that flies could actually distinguish between different strains of the same species of yeast. We frequently talk about strains of yeast used in making specific types of wine. There is, however, no reliable taxonomic or physiological procedure whereby such strains can be differentiated.

I'm sure that you are all aware that the fruit fly is an extremely important animal insofar as the processors of fruits and certain vegetables are concerned. The Food and Drug Administration just doesn't seem to like fruit flies meandering about the plant premises or remaining in food after it is processed. The flies ordinarily found on or about food are domesticated types, particularly *Drosophila melanogaster,* with more universal feeding habits and are often called "garbage flies". Nevertheless, it appears that they too prefer apiculate yeasts. For example, one of the dominant yeasts found in fermenting tomatoes in the field and in the crops of *Drosophila* collected around tomato plants, was a species belonging to an apiculate group. The importance of fruit

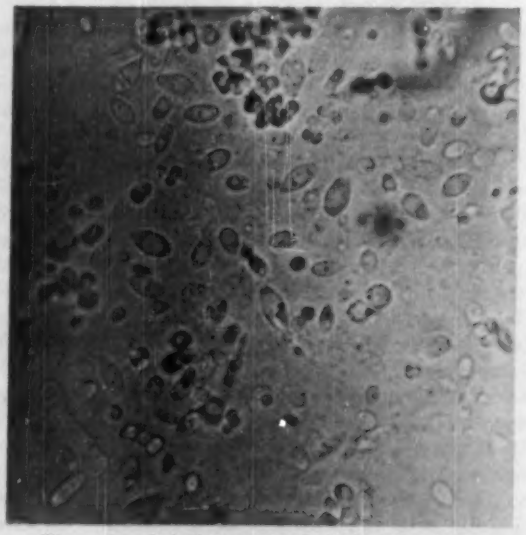


Figure 16. Apiculate yeast—fruit flies like them.

flies in the food industry has only served to stimulate a desire to obtain more fundamental information concerning the living habits of the little creatures.

THE FIG—ITS ROLE IN NATURE'S YEAST ECONOMY

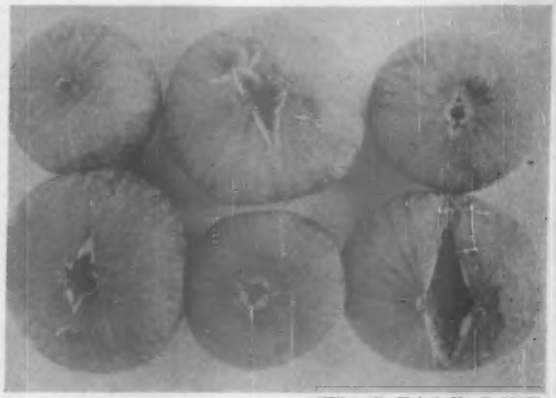
Now I should like to tell you a little about our work with figs. Botanically speaking, the fig fruit is a syconium, which means it is a hollow receptacle lined with flowers. It has a small opening at one end which enables it to serve as an ideal shelter and dwelling for small insects. Some species are self-pollinating whereas others are not. Because of these peculiarities the fig industry has experienced some very serious problems. This is particularly true of the Calimyrna fig which is pollinated by a wasp with pollen from the inedible Capri fig (Fig 17). Under

(Calif. Agr. Exp. Sta. *Bull. 506*)

Figure 17. Capri or male figs that produce the pollen.

commercial conditions the wasp *(Blastophaga psenes)* is reared in Capri fig trees located at some distance from the orchards of edible Calimyrna figs (Fig 18). The female lays eggs in ovaries of the flowers of the Capri fig and then the wasp causes galls to develop in which they remain until it is time to emerge. When the male *Blastophaga* emerges, it makes an opening for the female, at which time she is fertilized (Fig 19, 20, and 21). When the female wasp emerges it walks about the inside of the Capri or male fig, becomes covered with pollen, then leaves the fig to seek another where she may deposit eggs. If it happens to be a Calimyrna she enters, she cannot deposit eggs because the flowers are too tall to permit ovipositing (Fig 22). In her frantic movements, however, the fig becomes well pollinated. If she enters a male fig, on the other hand, ovipositing is easy and effective because the styles of the flowers are short (Fig 23).

Unfortunately, male figs become contaminated with a fungus known as *Fusarium moniliforme* or, as the industry terms it, "endosepsis", a disease that almost ruined the Calimyrna industry in California. Obviously, if the fungus is present, the wasp carries spores on its wings and body as well as pollen and



(Hilgardia Vol. 2, No. 7, 1927)

Figure 18. Calimyrna figs. Some are cracked and will undergo fermentation.

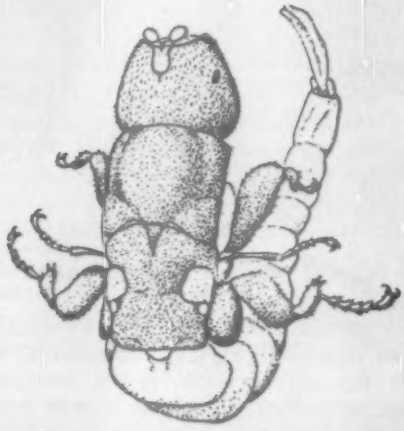


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Figure 19. Male blastophaga.

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Figure 20. Female blastophaga wasp.

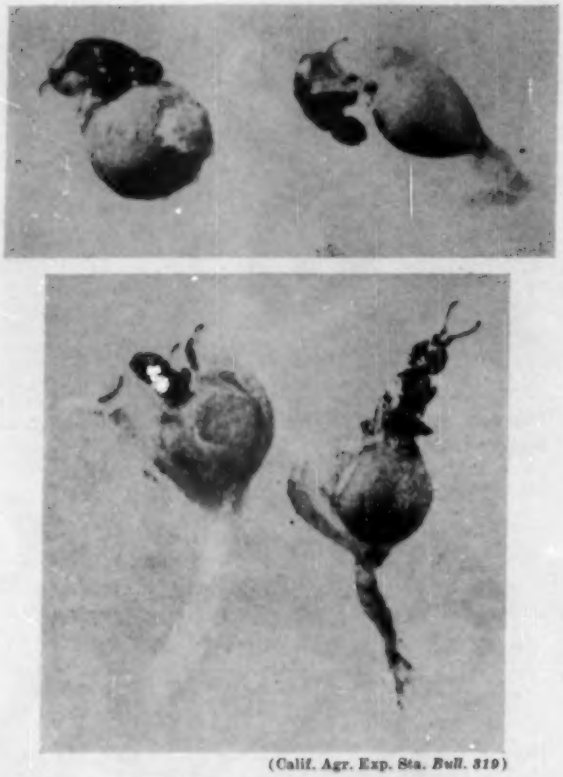

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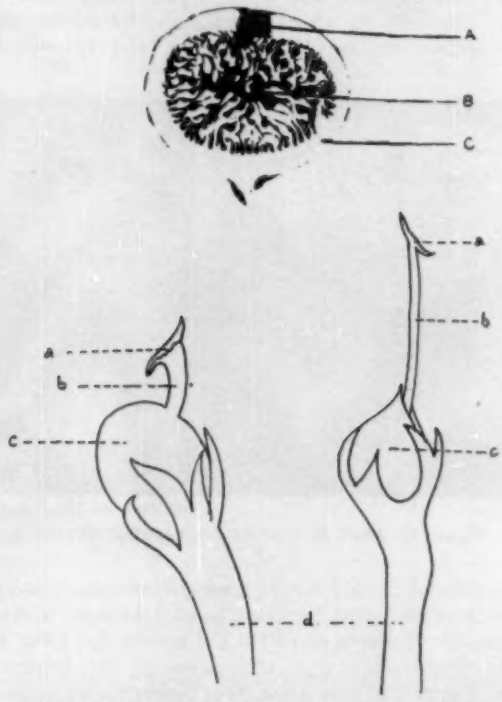
Figure 21. Male and female blastophaga emerging.

hence contaminates the edible fig in which the fungus grows very well (Fig 24). In order to combat this, male figs are harvested before emergence of the wasps, are cut open, and the interior surfaces sterilized by dipping in an antiseptic solution so when the wasps emerge, they are free of the fungus. This has proven to be a very effective procedure; however, there still remained problems in this complex fruit-wasp-fungus relationship. These problems were concerned, to a large extent, with yeast growth, fermentation, and acidification. Dr. Phaff in our laboratory has found recently that the wasp, even when in the gall, is not as free of undesirable organisms as previously believed. In addition to a bacterium *(Serratia)*, it carries *Candida guilliermondii*, a pseudomycelium forming yeast (Fig. 25). When a wasp enters the edible fig, therefore, it carries with it, in addition to pollen, *Candida guilliermondii* and *Serratia*. The edible fig becomes infected with *Candida guilliermondii*, and the bacterium, which proceed to develop slowly but not sufficiently to cause spoilage. During its slow growth, however, it does produce odors which seem to atract fruit flies. By the time the fruit is fully mature and the syrup concentration is quite high, these odors appear to develop sufficiently to attract fruit flies from nearby tomato fields, winery pomace piles, decaying mulberries, etc. These flies carry with them, in addition to fungi, spoilage yeasts and vinegar bacteria. Now, you may recall that I indicated that fruit flies have a high preference for apiculate yeasts. The evidence obtained by Dr. Phaff coincides with this. When the fruit flies enter the figs, they deposit apiculate yeasts, which start fermentation that may be so severe that syrup drips out of the eye of the fig (Fig 26). Fruit fly larvae start growing and then we have a situation that the Food and Drug Administration considers, if I may put it mildly, undesirable.

Enter the beetle. The story does not end here, however, for the dried fruit beetle now comes into the picture. It lives in fig orchard soils, and when the odors of fermentation come to the attention of this insect, it too is attracted to the figs. The dried fruit beetle leaves the soil and enters figs that fall on the ground and then eventually gets into fruit on the trees. This beetle also carries yeast that can participate in the destruction of the fig. Therefore, we made a study of the eating habits of the dried fruit beetle, the number of yeasts per gut, and the rate of digestion of yeasts ingested. The gut of a dried fruit beetle contains relatively few yeasts as compared with the fruit fly. Apparently, this is because the dried fruit beetle has an exoskeleton which does not permit the gut to expand as in the case of the fruit fly. Our studies showed that the gut of the dried fruit beetle contained approximately 15,000 organisms after feeding. As in the case of the fruit fly, the rate of digestion is dependent to a considerable extent on temperature. At 25° C., digestion was literally complete in 24 hours (Fig 27).



Legend: A) ostiole, B) inflorescence, C) receptacle, a) stigma, b) style, c) ovary, d) pedicel.

Figure 22. Male and female flowers.

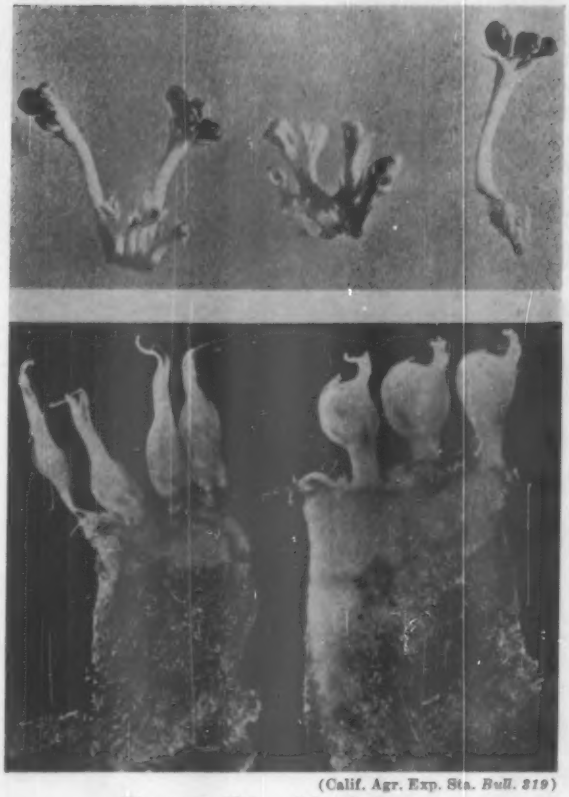


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Figure 23. Male and female flowers.

An intriguing series of tests was conducted to determine the attractivity of specific yeast, mixtures of yeasts, vinegar bacteria or mixtures of yeast, vinegar bacteria and fruit, to the beetle. These tests were conducted by exposure of the insect, under very carefully controlled conditions, to a series of vials arranged in a circle. Each vial contained a different substrate as indicated above. Starved beetles were placed in the center of the circle and permitted to choose the vial in which to feed. As may be expected, they visited a number of the vials before actually choosing the one in which to feed (Fig 28). A mixture of 3 yeasts most commonly isolated from the beetle or the two most commonly isolated yeasts plus vinegar bacteria showed the greatest attractivity. The most attractive yeasts were *Candida krusei* and the apiculates *Hanseniaspora* and *Kloeckera*.

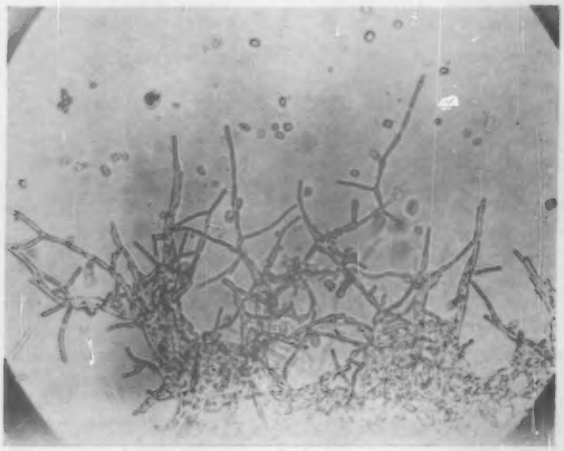

Figure 25. Candida guilliermondii, a pseudomycelium forming yeast.

But the story does not end here. We find that sugar-tolerant yeasts occur in the dried fig. The concentration of sugar is quite high in the dried fruit, being as much as 60%. Sugar-tolerant species of

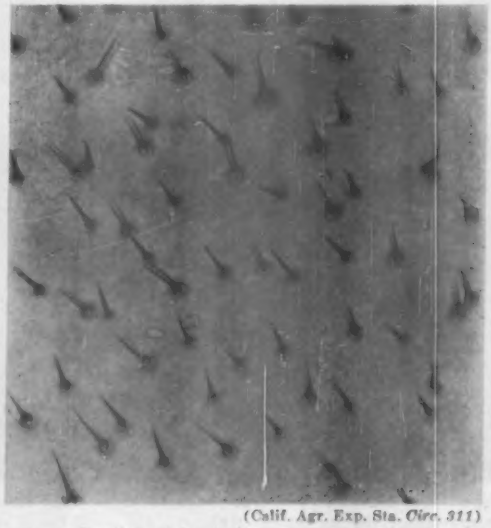

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Figure 24. Portion of blastophaga wing with fungus spores.

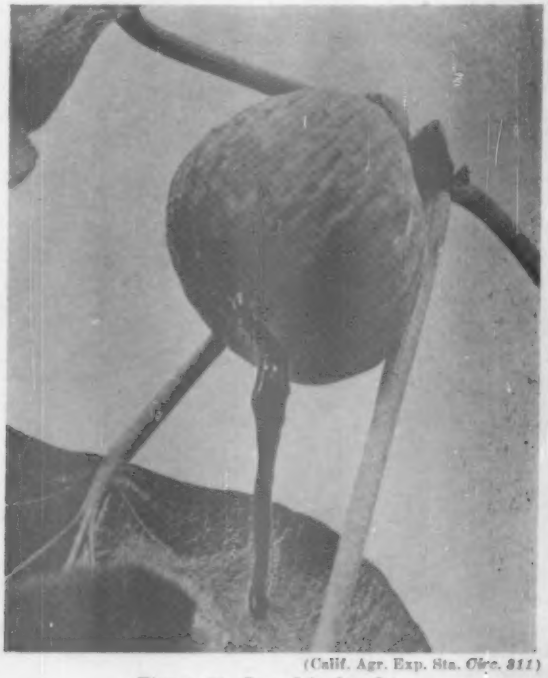

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Figure 26. Sour dripping fig.

RATE OF DIGESTION OF YEASTS BY CARPOPHILUS HEMIPTERUS AT 25° C

TIME AFTER FEEDING hours	AVERAGE NO. OF VIABLE CELLS	
	C. krusei	H. valbyensis
0	15,000	15,300
2	300	300
8	40	50
24	2	3
36	0	0

Figure 27. Rate of digestion of yeast by the dried fruit beetle.

Saccharomyces can be present when the fig is dried. They grow slowly and cause an incipient fermentation. It is uncertain as to how these get into the figs, but the presumption is that they are present during the early stages of maturation in very small numbers. Because of competition, however, they cannot grow very rapidly. After the sugar in the fig becomes concentrated as a result of drying, other organisms cease to grow and it appears that sugar-tolerant forms can then take over, although they grow slowly. These are the organisms that have given trouble during storage and after processing and packaging. In order to cope with them, it has been necessary to dry the fruit adequately, hold it in cold storage, or process it with care, and in some cases treat the figs with a gas that will kill these yeasts as well as sugar-tolerant molds.

SUGAR-TOLERANT YEASTS

While on the subject of sugar-tolerant yeasts, I would like to discuss briefly a few other problems attributable to these yeasts. At one time it was considered that the white substance forming on prunes always consisted solely of sugar crystals (Fig 29). We have found, however, that this can be a mixture of yeasts and sugar crystals. The yeasts present are usually those that can tolerate high concentrations of sugar. When dried prunes are stored in humid or unventilated areas, however, surface absorption of moisture may enable other yeasts to grow. The yeasts generally isolated are *Saccharomyces* or *Schizosaccharomyces*. The latter can be easily overlooked unless an enrichment medium containing about 40% sugar is used for isolation.

There is an organism known as *Saccharomyces rouxii* which can tolerate extremely high concentrations of sugar. Apparently, directly after isolation from substrates with a high sugar content, this species is very sensitive to slight changes in osmotic pressure which will either inhibit or permit its growth. If a small amount of sugar with a higher molecular weight is mixed with one with a lower molecular weight, it is quite possible that the difference may be sufficient to permit this organism to grow. It has been isolated from honey, molasses,

DEVICE FOR DETERMINING FEED PREFERENCE

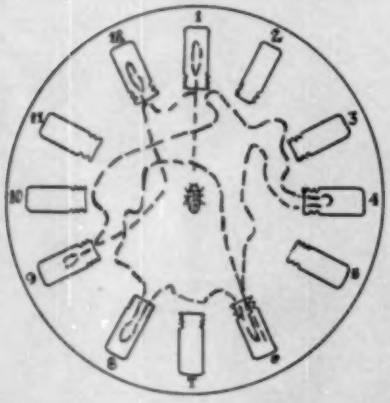

Figure 28. Arrangement for testing food preference of the dried fruit beetle. Note example of movement of the beetle before feeding.

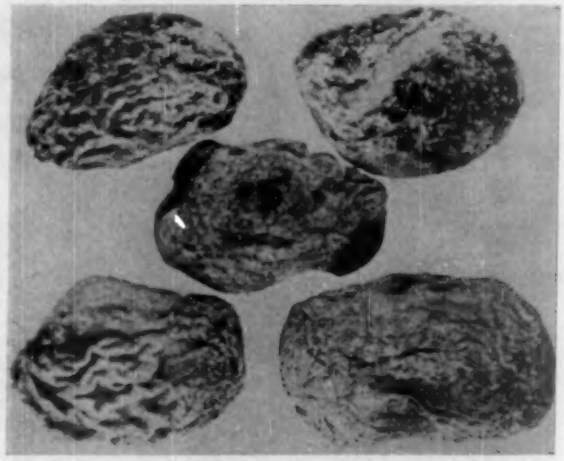

Figure 29. Sugared prunes.

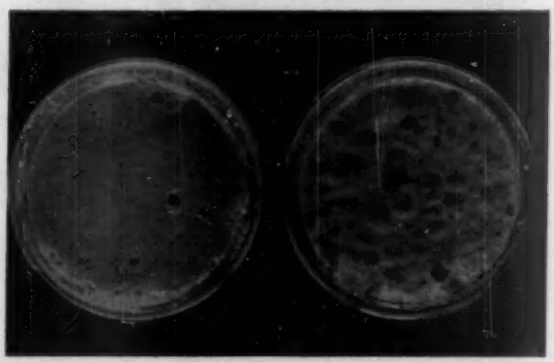

Figure 30. Tom and Jerry mix. Sugar-tolerant yeast causing fermentation of the jar on the right.

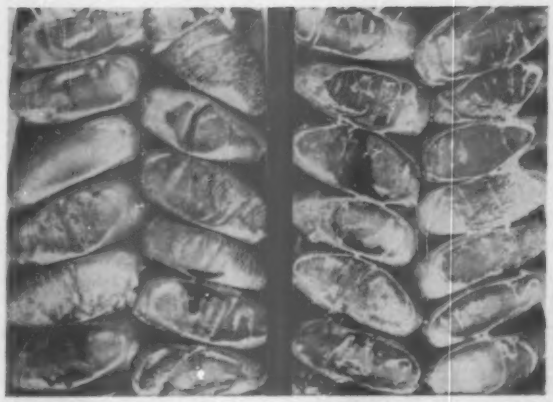

Figure 31. Packed dates. Right pack being fermented by sugar-tolerant yeast.

candy, "tom and jerry" mix, dates, etc. (Fig 30 and 31). The control of these organisms usually lies in good practices with respect to sanitation, and a realization of the conditions under which they may grow. The formation of a film of moisture on the surface of the food commodity is a very important consideration.

It has always been of interest to us that yeasts tolerant to high concentrations of sugar are not necessarily tolerant to high concentrations of salt. There are yeasts that can grow on brine solutions containing over 24% of salt. This is nearly saturation. These yeasts, on the other hand, generally cannot tolerate high concentrations of sugar. The salt-tolerant yeasts usually can grow as films on pickle, ham, vegetable and other brines. These are common species of *Debaryomyces* (Fig 32). They also grow in salted meats and fish. As a matter of fact we, in collaboration with Dr. Williams of Texas, have studied yeasts occurring on shrimp isolated from the Gulf Coast product. A number of these yeasts could grow in a medium containing 16% salt whereas others were less tolerant to salt. Yeast occurring in strong brines are commonly found on the surface, although certain ones occur below the surface. Their physiological activities are certainly of importance to the food industries. Some of them can utilize lactic acid and thereby change the conditions in pickle vats sufficiently to permit spoilage. The surface films can be controlled by exposure to sunlight or by covering with oil. According to Etchells, subsurface flora in pickle brines usually consists of different yeasts, namely *Brettanomyces* and *Torulopsis*. They utilize sugar which is important in lactic acid formation and may be instrumental in the formation of bloaters (gassy pickles). In olive brines the flora seems to change with time as shown in Figure 33.

There are many other interesting environments that could be discussed from the standpoint of yeasts.

YEAST FLORA CHANGE IN BARRELED OLIVE BRINE

ORGANISM	WEEKS 2-9	WEEKS 12-16
C. parapsilosis	3	–
C. krusei	40	–
C. tenuis	3	–
P. membranaefaciens	5	13

Figure 33. Yeast flora in olive brine.

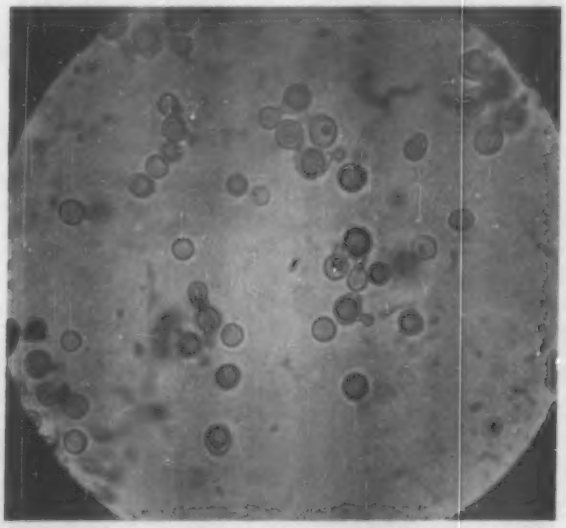

Figure 32. Yeast from (Deboryomyces). That forms a film on a pickle pork vat.

Figure 34. The world I lived in.

It is impossible to cover these at this time. I would merely point out that we have observed interesting cases of spoilage in salad dressing which contains sugar, vinegar and starch, wines (clouding), and even in boric acid solutions brought to us by a panicky pharmacist because his solutions were turning red. There are yeasts that prey on humans and animals. These are important in the field of medical science known as medical mycology. Others are plant pathogens and are not only important to the plant pathologist but also to the food technologist, especially if they appear in fruits and other plant products to be processed. They may occur in dairy products and fatty foods. There are yeasts that split fats. On the other hand there are yeasts that can grow on certain cereals (for example rough rice stored in sealed bins) and cause starch breakdown. The yeasts responsible are rather unusual organisms and appeal to one's imagination. It is needless to say that certain types of yeasts are commonly flying around in the air.

A FASCINATING AND STIMULATING WORLD

Truly the ecology of yeasts is a fascinating and stimulating area of research for a person with biological inclinations. It is equally stimulating to a food technologist because of the background information and understanding one can obtain of certain processes of nature that are so important to the food industries. Now that I have come to the end of my story, I hope that I have stimulated your interest and that I may have transferred just a little of my enthusiasm to you. I am most grateful to the Institute of Food Technologists for the opportunity to address you as Appert Medalist of 1957, for it has given me an opportunity to tell you about the world I lived in (Fig 34).

Non-destructive Measurement of Internal Color of Tomatoes by Spectral Transmission

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Color is one of the most important quality factors of tomatoes *(8, 13)*. Human evaluation has been and still is the accepted method of scoring tomatoes for color, although it is well known that such evaluation is subject to serious errors *(6, 12)*. Factors such as eye fatigue, lack of color memory, variations in color discrimination between individuals, and variations in lighting conditions greatly influence the decision of an individual in scoring the color of a given sample.

In processing into tomato juice, puree, or as canned tomatoes, the interior color of the tomato is of greater importance than the external color. Such color evaluation of tomatoes requires a high degree of accuracy because the difference in color among tomatoes is usually quite small. This has led to considerable research in developing instruments which could serve as a standard in evaluating color of red tomatoes. Instruments are commercially available for measuring the average surface reflectance of fruit *(1, 4, 5, 11)*, but surface reflectance is not an adequate indication of internal color of tomatoes *(7)*. The need of a method which would indicate the internal color of red tomatoes led to the development of a procedure to juice a sample of tomatoes and measure the color of the juice on a suitable color instrument such as the Hunter Color and Color Difference Meter or the Agtron Model F *(6, 7, 12)*. An alternative method has also been developed in which an instrument measures the reflectance of the cut surface of the halves of a tomato *(14, 15)*.

A non-destructive method of indicating internal tomato color would be useful to the researcher in observing changes in color as related to certain factors such as storage conditions or variety. The simplicity and ease of operation of a non-destructive technique would be of considerable importance to the grower and the inspector. The speed with which optical and

electrical measurements can be made limits the speed of operation for this technique to how fast tomatoes can be handled individually. Thus, color evaluation of every tomato entering a processing plant is theoretically possible. The technique could also be applied to the fresh tomato industry.

SPECTRAL TRANSMITTANCE OF BIOLOGICAL MATERIALS

An extension of an earlier line of investigation in this laboratory on defect detection in eggs led to the development of instrumentation and methods for recording the spectral transmittance curves of various agricultural products *(2, 3, 10)*. Figure 1 shows the instrumentation set-up in operation. Principal parts are diagrammed in Figure 2. This unit has been given the name "Rephobiospect" coming from the words *Re*cording *Pho*tometer for *Bio*logical *Spec*tral *T*ransmission.

In instruments for measuring spectral transmittance of substances it is customary to have a system which has the same response for all wavelengths. However, there is such a great change in the transmittance of a tomato between the blue-green and the red-infrared part of the spectrum that it was advantageous to be able to adjust the sensitivity of the system in one region relative to the other. This was accomplished by adding the output of two phototubes,

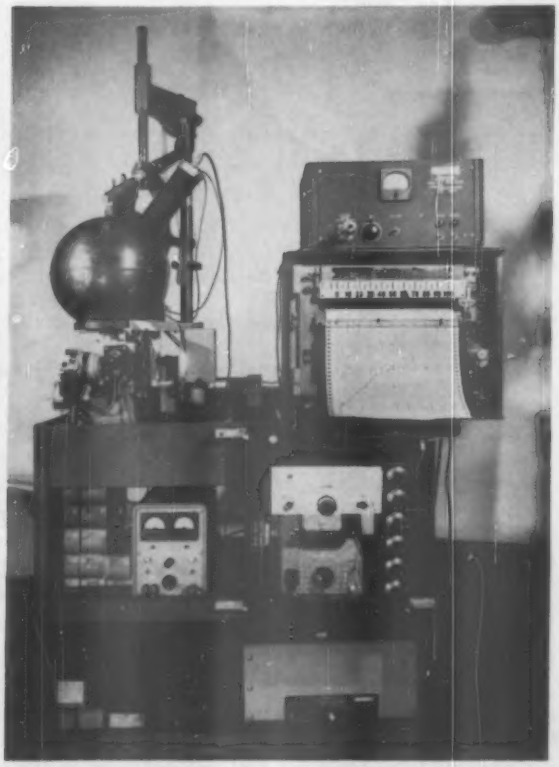

Figure 1. The Rephobiospect: Recording Photometer for Biological Spectral Transmission.

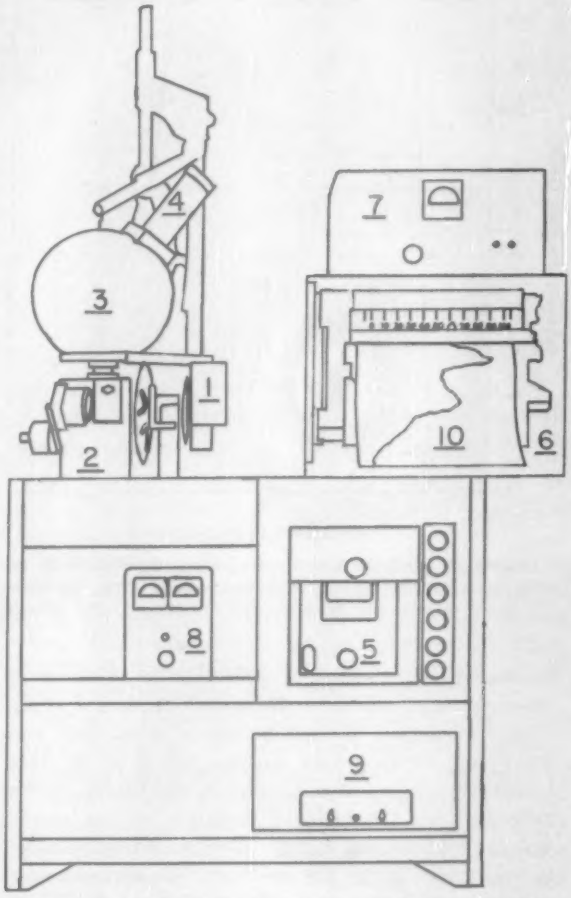

Figure 2. Principal parts of the Rephobiospect: 1. Light Source; 2. Monochromator; 3. Integrating Sphere; 4. Phototube; 5. Amplifier; 6. Strip Chart Recorder; 7. High Voltage Supply for Infra-Red Phototube; 8. High Voltage Supply for Visible Phototube; 9. Voltage Regulator; 10. Spectral Transmittance Curve of a Red Tomato.

one for the red and near infrared, and the other for the blue and green part of the spectrum with the sensitivity of each phototube independently adjustable. To plot the true spectral transmittance curve of an intact fruit it is necessary to make calculations which compensate for the spectral characteristics of the system. Because of the large difference in absorption between the various parts of the spectrum it is necessary to plot the data on 4 or 5-cycle semi-log paper.

Tomatoes were prepared for measurement in the Rephobiospect as follows: the stem of the tomato was removed, and the tomato was washed and cleaned. The Rutgers variety was used. Defective or deformed tomatoes were not included in any of the experiments. In placing the tomato in position in the integrating sphere, the fruit was placed in the normal upright position and illuminated on the blossom end with monochromatic light (see Figure 5).

Figure 3 shows the transmittance curves for 3 to-

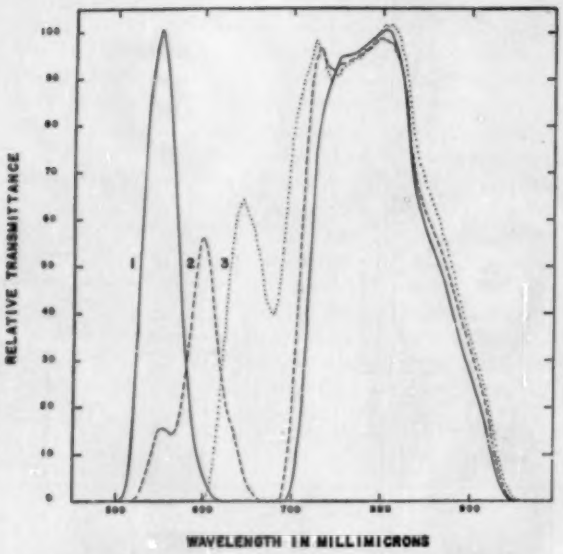

Figure 3. Spectral transmittance curves as recorded by the strip chart recorder of the Rephobiospect for three tomatoes: (1) green tomato, (2) red-green tomato, and (3) red tomato.

matoes (green, red-green, and red) as recorded on the strip chart recorder. Since the path-length of the light transmitted through a tomato is not held constant and certain other factors influence the total transmittance, no significance is attributed to the ratio between the incident radiation on the tomato and the transmitted energy. The peak transmittance is arbitrarily given the value of 100 and all other values are then measured relative to the peak. Figure 4 is a plot of the true spectral transmittance properties of the same tomatoes shown in Figure 3. The minimum transmittance for the green tomato occurs at 670 mμ corresponding to the maximum absorption of chlorophyll. At this wavelength the transmittance is about 1.5×10^{-4} relative to the peak transmittance of 100 at 820 mμ. Thus the transmittance at 670 mμ changes more than 100,000 times as a tomato changes from green to red. The relative change in transmittance of the 550 mμ region is of the same order of magnitude although in the opposite direction.

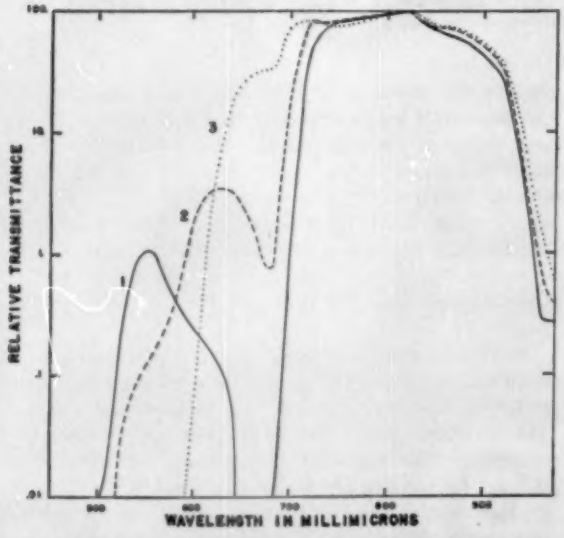

Figure 4. Spectral transmittance curves corrected to compensate for the spectral characteristics of the Rephobiospect. Curves are for the same tomatoes as Figure 3.

The distribution of the transmitted energy around the surface of the tomato was measured, using a specially constructed scanning photometer. This distribution as a function of angular position is shown in Figure 6. It is evident that the highest energy level

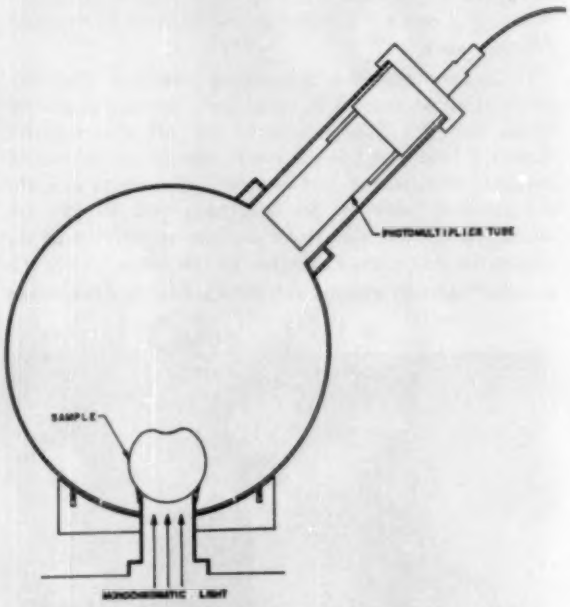

Figure 5. Cross-section of the integrating sphere with a tomato in position.

is closest to the light source, and the energy level decreases logarithmically as the angle a increases.

In order to apply the transmittance technique to a practical problem it is necessary to measure the transmittance of at least two wavelengths and use the ratio of these values as the criterion of color. This gives a number which is insensitive to changes in gain of amplifier, size of tomato, and other factors which influence the overall transmittance. Since the part of the spectrum in which the spectral transmittance can be measured for both a green and a red tomato without requiring a highly sensitive instrument is relatively narrow (Figure 4) (610 mμ to 630 mμ), it was decided to select one pair of wavelengths to indicate color in red tomatoes and another pair of wavelengths to indicate the color of green tomatoes.

INDICATING COLOR OF TOMATOES FOR PROCESSING

The selection of wavelengths to indicate color in red tomatoes was based on finding a number which would change in value as much as possible going from a tomato of poor color (culls) to one of full red color (high U. S. No. 1). One of the greatest changes in the spectral transmittance curve of a tomato as the fruit develops more red color is in the chlorophyll absorption region at 670 mμ as shown in Figure 4. The transmittance at 670 mμ increases as color develops. Therefore, selection of another wavelength at which the transmittance decreases will yield a ratio which will change in value several times going from one to the other of the two extremes of color for red tomatoes.

The limiting factor in finding the second wavelength is that the transmittance should be high enough so that an extremely sensitive instrument is not necessary. These considerations led to the choice of the ratio of transmittance at 620 mμ vs. 670 mμ. This ratio $T_{620\ m\mu}/T_{670\ m\mu}$ changes in the order of 30:1 as a tomato ripens from yellow-red to full red color.

A simple photometer unit was constructed to test the performance of this transmittance-ratio measurement for indicating color of tomatoes. This photometer uses a microscope illuminator (100 watts) to illuminate the blossom end of the tomato through interference filters. The filters, of 10 mμ half-band width interference type peaked at 620 mμ and 670 mμ respectively, were mounted in a slide to permit first one and then the other to be introduced. The transmitted light was measured by a multiplier type phototube mounted to view the side of the tomato at a right angle to the incident light. Figure 7 shows the arrangement of components for this photometer. The

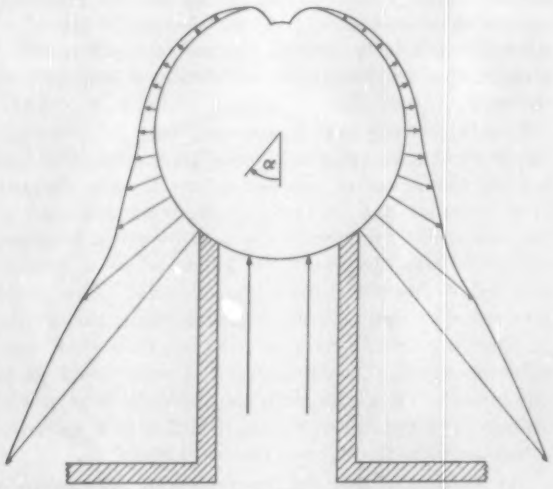

Figure 6. Distribution of energy transmitted through a tomato when illuminated on the blossom end. The length of the lines for the transmitted energy are proportional to the intensity. This distribution of energy is for light of 640 mμ wavelength.

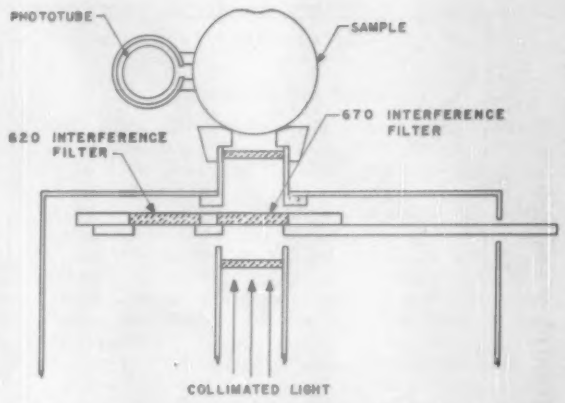

Figure 7. Cross-section of the filter photometer for measuring the transmittance ratio $\frac{T_{620m\mu}}{T_{670m\mu}}$ of red tomatoes.

output of the phototube was indictaed on a sensitive Vacuum-Tube Volt-Meter.

The Hunter a_{Rd}/b_{Rd} ratio of the juice was used as the standard in comparing the transmittance measurement with accepted methods of indicating tomato color. The tomato juice was extracted with a Silex-Enterprise food chopper with a juicer puree attachment having a screen with .034″ holes.

Initial correlations were based on making both measurements on individual tomatoes. This yielded a correlation coefficient at about −0.75. An attempt at making repeated transmittance measurements on the same tomato showed that this did not improve the correlation. Subsequent tests were based on transmittance measurement on individual tomatoes and the Hunter a_{Rd}/b_{R1} ratio measurements on the juice extracted from a grouping of four tomatoes. The transmittance measurements for each of the four tomatoes were combined by the geometric mean and a correction for tomato size was applied as follows:

$$\text{Log of the Weighted Geometric Mean} = \frac{\sum_{j=1}^{j=n} \log \left(\frac{T_{620\ m\mu}}{T_{670\ m\mu}}\right)_{ij} \frac{V_{ij}}{V_i}}{n}$$

V_{ij} = Volume of juice extracted from an individual tomato
V_i = Volume of juice from a group of tomatoes
i = Number of group
j = Number of a tomato in a group
n = Number of tomatoes per group (four in above tests)

The correlation between the log of the weighted geometric mean and the a_{Rd}/b_{Rd} ratio was −0.95. (Figure 8).

Mavis correlated measurements on individual tomatoes made by the Agtron E with measurements made on the Hunter Color Difference Meter *(9)*. His results showed that when 10 or more tomatoes in each

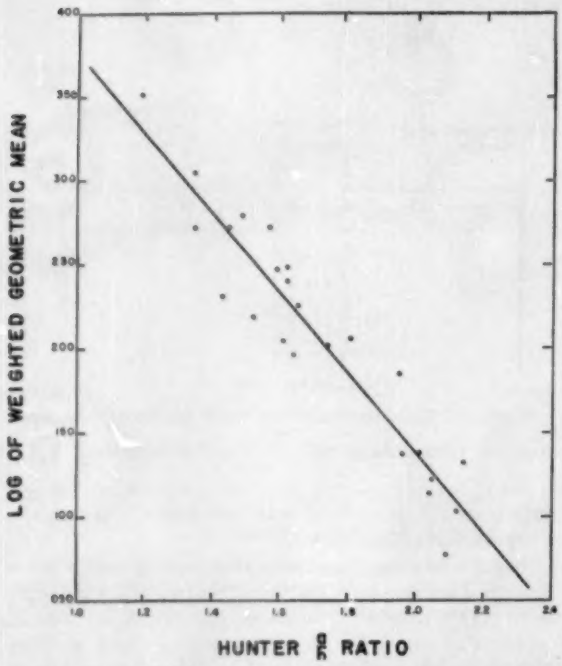

Figure 8. Correlation of the transmittance measurement on individual intact tomatoes with the Hunter a/b ratio of the extracted juice. The correlation coefficient, −0.95, is significant at the 0.01 level.

group were tested a correction for the size of the individual tomatoes was not necessary. This indicates that it may be possible to improve the transmittance-Hunter correlation even more, and the size correction may not be necessary when ten or more tomatoes are included in each group.

PREDICTING COLOR CHANGE

In harvesting of tomatoes for fresh market it is advantageous to be able to predict the time required for a tomato to reach full color. By superimposing curves drawn on successive days for the same green tomato, it was observed that the first change in the spectral transmittance curve was an increased absorption at 520 mμ while the peak transmittance occurring at 545 mμ did not change. Therefore, a ratio between these two wavelengths, $T_{520\ m\mu}/T_{545\ m\mu}$, was used as a criterion of color for green tomatoes. Further investigation showed some degree of correlation between this ratio and maturity of green tomatoes as measured by the days until ripening. This measurement was found to be too inaccurate to separate immature tomatoes from mature green tomatoes, but tomatoes having an amber internal color previous to showing external color can be separated from tomatoes which are totally green.

Although this work did not result in a method to separate immature tomatoes from mature green tomatoes, the technique could be applied to predicting the time required for tomatoes, which have started to change color, to develop full red color. The two transmittance ratios described can be combined as follows: $\frac{T_{670\ m\mu} - T_{520\ m\mu}}{T_{620\ m\mu} + T_{545\ m\mu}}$. This value can be used to indicate the color of any tomato varying in color from green to red. Figure 9 shows how this value changes with time as a tomato ripens while being held at 75° F. The portion of the curve which is negative is essentially the $T_{520\ m\mu}/T_{545\ m\mu}$ ratio and the positive values of the curve are essentially the reciprocal of the $T_{620\ m\mu}/T_{670\ m\mu}$ ratio.

If the transmittance at wavelengths longer than 670 mμ is disregarded in the curves of Figure 3, it is apparent that there is another characteristic of the

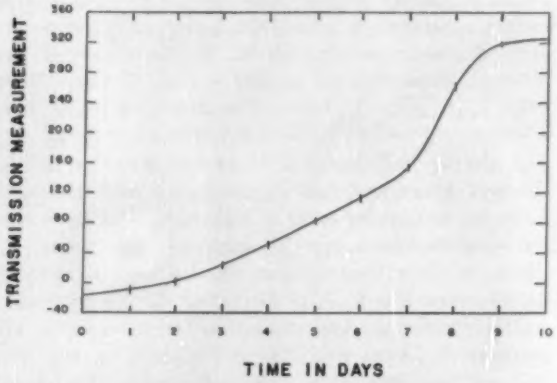

Figure 9. Transmittance $\frac{T_{670\,m\mu} - T_{520\,m\mu}}{T_{620\,m\mu} + T_{545\,m\mu}}$ time curve for a single tomato. At 0 days the tomato was completely green, at 1 day the tomato began showing color, and the external color was almost entirely red on the fourth day.

curves which would be indicative of the ripening process in a tomato: i.e., the wavelength of the peak transmittance in the visible part of the spectrum. A plot of this transmittance measurement vs. time is shown in Figure 10.

It is interesting to compare these time-color curves. The peak transmittance is a very good method of following the ripening process as the tomato changes from green to red. In fact this criterion was used as the measure of ripeness in the tests on green tomatoes where it was necessary to know when a tomato reached a specific degree of red color. The ratio measure does not show much change while the tomato is changing from green to red, but does show considerable change as additional red color develops in the tomato. Thus, this ratio measurement is very well suited to evaluating the small differences in color which occur with tomatoes for processing.

At the time of this writing a portable instrument is being developed expressly for measuring color of tomatoes. This instrument is designed to make the two ratio measurements for tomatoes described in this paper. Another portable instrument is being de-

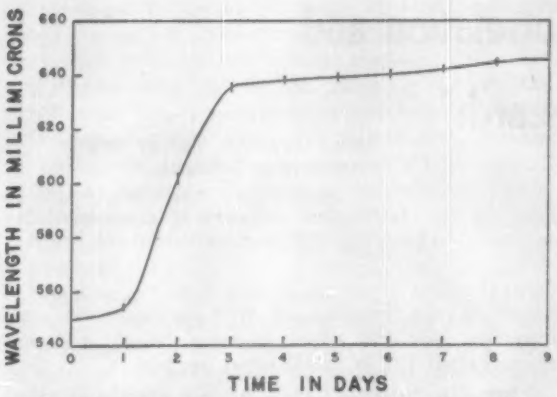

Figure 10. Change in wavelength of the peak transmittance of a tomato vs. time. The time-color relationship is the same as for Figure 9 since both curves are for the same tomato.

signed to measure the wavelength of peak transmittance of visible light of intact fruit.

SUMMARY AND CONCLUSIONS

Instrumentation techniques have been developed which measure and record the spectral transmittance characteristics of intact tomatoes. This type of measurement expresses the internal color of a tomato without damage to the product. A ratio between the transmittance of light of 620 mμ wavelength and 670 mμ is a satisfactory indication of color of red tomatoes as shown by a high degree of correlation with the Hunter a_{Rd}/b_{Rd} ratio of the extracted juice. The ratio of the transmittance of light of 520 mμ wavelength vs. the transmittance of light of 545 mμ wavelength can be used to separate tomatoes which have an external green appearance with an interior amber color, from tomatoes which are green throughout. A combination of these two transmittance measurements can be used to evaluate the color of any tomato. The selections of wavelengths of light to be used in these measurements are not to be implied as a measure of a single pigment or any combinations of pigments in tomatoes. These wavelengths were selected solely as a criterion of tomato color that would yield a high degree of correlation with accepted methods of indicating tomato color.

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The SQC Approach to Multiple Correlation and Regression in Food Packaging Research[a]

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VARIATION IN SHELF LIFE, a major problem in food packaging research, is influenced by causative factors in themselves inherently variable. Among the chief causative factors of variation in shelf life are: (a) composition of the raw product; (b) processing techniques; and (c) packaging materials.

Composition of the raw product. Food products, whether animal or vegetable, are affected by many factors during growth. Some of these factors, such as the amount of fertilizer applied to a field or the amount of food fed to cattle, can be controlled at specified levels. Other factors, such as climatic conditions during the growing period, or the actual quantity of feed ingested by each animal cannot be controlled. In adition, the uncontrolled factors can show considerable variation from season to season, or from growing area to growing area. The finished food product retains a certain element of the natural biological variation of the raw food source. This variation in food composition can directly affect the shelf life of the food product: as the composition of the food product varies, the shelf life varies to some degree.

Processing techniques. Unit operations in the cannery are not absolutely identical from day to day and introduce a second source of variation in the shelf life of the food product. Blanching times may vary from day to day or from one lot to another; exhaust times for air removal, or filling temperatures may vary slightly from hour to hour within any one day. Yet some variation in the canning or packing procedure must be tolerated if the food processor is to operate economically under normal commercial canning conditions. However, variations can cause fluctuations in vacuums which, in turn, can result in variation in shelf life of the finished food product.

Packaging materials. Although certain latitudes in packaging materials and manufacturing methods are tolerated in economic commercial production, both container manufacturers and materials suppliers of container components are expected to control their products well within commercially specified limits to insure acceptable container performance and adequate shelf life. Nevertheless, variations in certain packaging materials or metal container components can result in a wide variation in the appearance or flavor of the product as well as container performance, and will affect, to some extent, the commercial shelf life of the finished product.

From the foregoing it is readily discernible that variation in shelf life of commercially canned foods is additive and that the variation obviously is the result of the operation of multifactor system. However, in the majority of cases, a small number of the factors account almost entirely for the total correlation. When a combination of many measurable factors produces one result, multiple correlation and regression methods can be applied to isolate the dominant factors responsible for variation and to evaluate the relative effect of each factor. These methods are quite time-consuming, particularly when many factors are present. The formal approach has been to delete factors one by one from the complete matrix until a dropping off point is reached. As described in this paper, the authors deviate somewhat from the formal approach in the application of these techniques to a seven factor food research problem. The technical interpretations of the statistical results are also presented.

MULTIPLE CORRELATION AND REGRESSION METHODS

It is usually possible to list the various factors which may conceivably influence the shelf life of a canned food product and to obtain simultaneous measurements of these factors. However, under normal commercial conditions, the levels of all of these factors cannot be specified in advance. For example, it is impossible to specify in advance that the pH of the natural food product shall be exactly 4.2 or that the sealed container after processing and cooling will contain exactly 10 in. of vacuum. The fact that it is not practical to impose such rigid conditions upon the collection of these data obviates the use of many desirable factorial and block designs. Under these circumstances the best that can be done is to take samples and to record the observations as they actually occur in the product. Each factor in the food packaging problem then constitutes part of a group of conditions contributing to the potential failure of the canned food product. Therefore, as applied to these problems, multiple correlation and regression techniques are interpreted as describing relationships rather than indicating absolute cause and effect.

The formal application of multiple correlation and regression methods usually requires a large number

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

of experimental units. However, in food packaging problems, only a small number of test packs of any particular product are usually available for study, and it is assumed that the test packs are random samples drawn from a homogeneous population. There is no reason to assume that every measurable container or product factor will be directly related to the shelf life of the product. However, to minimize the risk of overlooking a potentially influential factor, data should be collected on as many measurable factors as is practical.

When only a few test packs are available (15 or less), the number of measurable container and product factors can become disproportionately large in relation to the number of available experimental units. Although the nature of the data dictates the use of multiple correlation and regression methods, the ability of these methods to extract information from data is sharply reduced as the sample size decreases and for this reason, use of these methods is too frequently avoided. The statistical quality control (SQC) approach is therefore presented as one solution to this ever present problem of small sample sizes in food packaging research.

THE SQC APPROACH TO MULTIPLE CORRELATION

In many fabricating industries, the ability of SQC techniques to isolate dominant factors in a multicause system has been demonstrated *(5)*. In essence, the SQC approach is based on the premise that out of the many factors which could conceivably influence a result, only a few will be dominant. Marked progress is achieved if the important factors are isolated and the minor factors deleted with a minimum amount of effort. Likewise in a formal multiple correlation study, only a few of the many possible factors have a major bearing on the problem *(6)*. This similarity is frequently overlooked.

In applying the SQC approach to multiple correlation problems dealing with shelf life of canned foods, it must be borne in mind that the number of observations available for study will usually be small. Sometimes only 10 to 15 test packs will be available for inclusion in the analysis. If all of the factors regardless of their importance are included in the multiple correlation, too many degrees of freedom—affecting the precision of the estimate of shelf life—will be lost. However, if the independent factors are added to the correlation analysis one by one until the dominant factors are isolated, the loss of degrees of freedom is minimized. Therefore, the problems that must be solved are: "What factors should be included?" and "What device can be used to estimate the effect of the selected factors upon the multiple correlation coefficient?"

The answer to the first problem depends upon the correlation of the independent product and container factors with shelf life and the presence of interrelationships between the independent factors. To arrive at an answer, it is necessary first to calculate the simple correlation coefficients. These correlation coefficients are then examined for indications of simple relationships between the product factors, the container factors, and the shelf life. Factors are selected for inclusion in the multiple correlation calculations based on their degree of correlation with shelf life. The two highest simple correlations, expressing the association between shelf life and the respective factors, are added together in a two factor multiple correlation matrix to determine whether or not the resultant multiple coefficient is higher than either one of the two simple coefficients. If the multiple correlation coefficient does not increase, the factor with the next highest simple coefficient is chosen, and so on, until either the multiple coefficient increases above the highest simple ones or until all of the factors have been combined with the simple coefficients. When two dominant factors have been located, a third factor, a fourth factor, and so forth are added to the first two, following the same procedure.

The answer to the second problem lies in plotting two graphs as the analysis proceeds. These graphs serve as visual aids to help in locating the dominant factors. When dominant factors are included in the correlation, the multiple correlation coefficient will increase. If each coefficient is plotted as it is calculated, the rate of increase will be greatest for the dominant factors and will diminish for the less influential factors. In other words, a few dominant factors can account almost completely for the coefficient resulting when all of the factors are included.

A second graph plotted as the analysis proceeds aids in locating the dominant factors. If the mean square of the unexplained variation is plotted as factors are added, a minimum point will result when all of the dominant factors have been included in the correlation analysis. This minimum point will be more pronounced when a small number of observations (15 or less) are available for study. The minimum mean square merely indicates that a balance has been reached between the loss of degrees of freedom and an increase in the amount of information regarding shelf life contained in the multiple correlation coefficient.

An additional device, a three dimensional plotting system, aids in the correlation analysis *(8)*. When the product or container factors are plotted on the x and y axes and the shelf life is plotted on the z axis, relationships between the product and container factors and the shelf life are simply located. This plotting also indicates the form of the relationships: that is, it yields information about the linearity of the relationships between shelf life and the independent factors. In the absence of a factorial design, the presence of joint effects and curvilinear functions is difficult to detect. The three dimensional plotting system gives some information about the existence of such relationships when a large enough sample size is available (10 to 15 test packs).

The detection of strong joint effects and curvilinear functions is important in the analysis. Nonlinear functions indicate factor combinations producing an

optimum or a maximum shelf life. When such relationships exist, the correlation coefficients associated with these functions may be added to the analysis to determine whether or not this nonlinear function strongly increases the multiple correlation coefficient *(6)*. If the correlation coefficient strongly increases, these nonlinear relationships have a real meaning in determining a long shelf life. Such additions, however, result in the loss of additional degrees of freedom. Consequently the increase in the multiple correlation coefficient must be quite marked to outweigh the loss of degrees of freedom when nonlinear functions are included in the analysis.

When a dominant nonlinear trend between shelf life and some of the independent factors has been shown, the correlation surface can be investigated to locate the maximum shelf life. Since the nonlinear trend observed on the three dimensional plot is obtained in the presence of concomitant factors, it is often desirable to eliminate the effect or the influence of these other factors during the investigation *(2)*. When the concomitant factors are delated from the data by the method described by Ezekial *(2)*, the best combinations of two single factors to produce a maximum shelf life are determined.

The following example illustrates the use of the SQC approach to multiple correlation and regression on data obtained at the Continental Can Company's Metal Research and Development Laboratories in Chicago.

Example of SQC approach. The objective of this study was to determine the dominant container and product factors in relation to the shelf life of canned tomatoes. Over a period of 7 years, 13 test packs were made of this product at various canneries throughout the United States. As much variation in the shelf life of canned tomatoes could be anticipated from packer to packer as from year to year.

The following container and product factors were measured in each of the 13 test packs:

Independent Variables:

Plate Coating	Container Variable A
Initial Vacuums	Container Variable B
pH of the Product	Container Variable C
	Container Variable D

Dependent Variable:

Shelf life of the product as measured objectively; that is, time to 25% failures under accelerated storage conditions.

One stable measurement for each of the factors was obtained from every pack included in the study. At the end of the experiment, every factor was correlated with every other factor, and these simple correlations are shown in Table 1. These simple linear correlations were obtained by the usual cross product method for obtaining simple linear correlation coefficients: that is,

$$r = \frac{\pm SP\,(xy)}{\sqrt{SSx SSy}}$$

where SP = sum of cross products
SS = sum of squares

As a second step, the factors were plotted in sets of two on the three dimensional graph with shelf life on the z axis. Container factor D showed a slight curvilinear trend with shelf life. All other factors, showed a linear relationship with shelf life and with each other. Hence, it was asumed that all of the factors, with the possible exception of Container factor D, would form a linear regression with shelf life.

An examination of Table 1 shows Container factor A to have the highest simple correlation coefficient, +0.6491. This value was plotted on a correlation graph as shown in Figure 1. The mean square of the deviations about the regression line was calculated in the usual manner *(7)* and this mean square, 24.5025, was plotted on a mean square graph as shown in Figure 2.

Container factor C showed the second highest simple correlation coefficient, +0.6137. Furthermore its intercorrelation with factor A was slight. The two

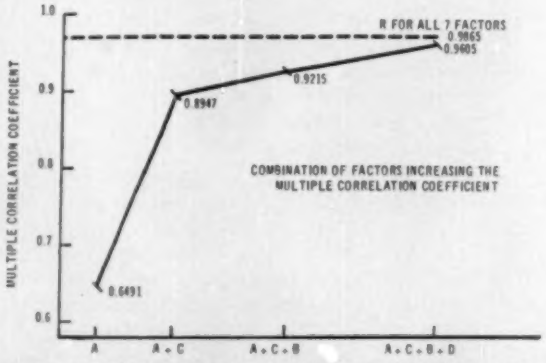

Figure 1. SQC approach to multiple correlation and regression in food packaging research.

TABLE 1

Simple correlation coefficients—shelf life studies on canned tomatoes

	Shelf life[a]	Cont. Var. B	pH of product	Cont. Var. D	Initial vacuum	Plate coating	Cont. Var. C
Cont. Var. A	+0.6491*	−0.1863	+0.1039	−0.3863	+0.3133	+0.1222	−0.0031
Cont. Var. C	+0.6137*	+0.0914	+0.3910	+0.7284**	+0.0364	+0.2789	.....
Plate coating	+0.3660	−0.1779	+0.2607	+0.3884	+0.3883	.....	
Initial vacuum	+0.3497	−0.1653	+0.4486	+0.0276	.....		
Cont. Var. D	+0.3151	+0.2747	+0.4047	.....			
pH of product	+0.2862	−0.2804	.....				
Cont. Var. B	−0.2811	.....					

[a] Time to 25% failures.
* Significant at the 5% level with 11 degrees of freedom.
** Significant at the 1% level with 11 degrees of freedom.

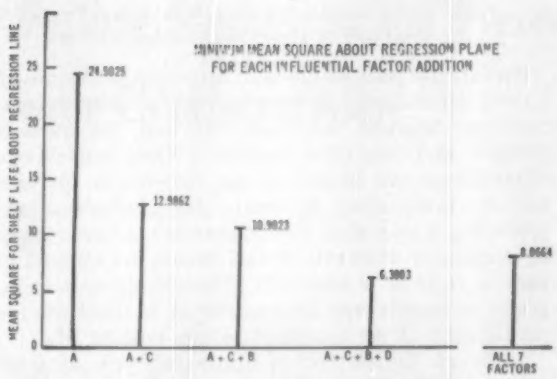

Figure 2. SQC approach to multiple correlation and regression in food packaging research.

factors were placed in a multiple correlation matrix and the multiple correlation coefficient was calculated, using the Doolittle Method *(3, 4)*. The resulting multiple correlation coefficient was 0.8947. The calculated mean square of the deviations about the regression plane was 12.9863. These values were plotted on their respective graphs. The multiple correlation coefficient (Figure 1) showed a marked increase and the mean square (Figure 2) showed a decrease. Hence, Container factors A and C were obviously dominant factors in regard to the shelf life of canned tomatoes. No other factor, when placed in the matrix with factor A showed as large an increase in the correlation coefficient or as sharp a decrease in the mean square as when factor C was present with factor A. The correlation surfaces between factors A and C and B and D are shown in Figure 3.

When a third factor was added to factors A and C in the multiple correlation matrix, Container factor B increased the multiple correlation coefficient more than did the remaining factors. The resulting coefficient was 0.9215 and the mean square of the deviations about the regression planes was 10.9023. The correlation coefficient was slightly increasing and the mean square was still decreasing. Hence, Container factor B was considered to be of importance in determining the shelf life of canned tomatoes. This factor actually diminished the shelf life as was shown by the sign of its simple correlation coefficient and by the sign of its regression coefficient (standard measure).

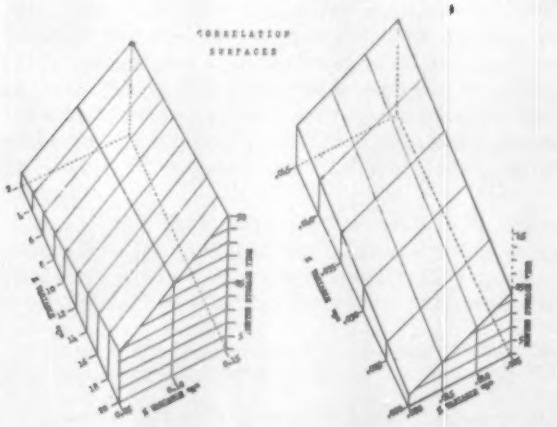

Figure 3. SQC approach to multiple correlation and regression in food packaging research.

Of the remaining four independent factors, only Container factor D increased the multiple correlation coefficient in the presence of Container factors A, C, and B. The coefficient increased to 0.9605 and the mean square of the deviations decreased to 6.3003 as shown in Figures 1 and 2. Container factor D was effective only after factor B was present. Furthermore, factor D had previously shown a slight curvilinear relationship with shelf life but a linear interrelationship with Container factor B. It was estimated that approximately 1.7% of the increase in the multiple correlation coefficient was lost by considering Container factor D as a linear variable. The loss of one more degree of freedom, however, would have nullified the increase in the multiple correlation coefficient. Hence the use of the linear form of factor D was justified in determining the influence of this factor on the shelf life of canned tomatoes.

It appeared that the dominant factors influencing the shelf life of canned tomatoes had been located. To give evidence of this fact, all of the remaining factors were included in the multiple correlation matrix. The resulting multiple correlation coefficient was 0.9685. The mean square of the unexplained variation about the regression planes increased to 8.0664. Hence, four factors accounted for 99% of the total correlation coefficient and these 4 factors gave a more precise estimate of the shelf life of canned tomatoes in this analysis based on 13 test packs. The statistical results are summarized in Table 2.

SUMMARY AND CONCLUSIONS

Variation in shelf life of canned food products is influenced by many factors among which are: (1) the inherent biological variation of the raw food product; (2) variation in canning techniques; and (3) variation in packaging materials. This variation

TABLE 2

Multiple correlation coefficients and mean squares about the regression planes of the deviations resulting from the combinations of various factors

Factors	Multiple correlation coefficient, R[a]	Degrees of freedom	Mean square of deviations [b]
A	0.6491	11	24.5025
A + C	0.8947	10	12.9863
A + C + B	0.9215	9	10.9023
A + C + B + D	0.9605	8	6.3003
All 7 Factors	0.9685	5	8.0064

[a] The multiple correlation (unadjusted for small sample sizes) was calculated by the Doolittle matrix system and is equal to: $R = \sqrt{\beta_1 \gamma_1 + \beta_2 \gamma_2 + \cdots \beta_k \gamma_k}$ where β is the regression coefficient in standard measure of each factor with shelf life, and γ is the simple correlation coefficient of each factor with shelf life.

[b] The mean square of deviations was calculaetd using the following equation: $1-R^2\ SSy/N-k-1$ were N=total number of test packs or experimental units and k=number of variables or factors.

is additive and is the result of a multifactor system. The fact that the levels of these factors cannot be specified in advance obviates the use of a factorial or block design. Therefore, to isolate the dominant factors responsible for variation and to evaluate the relative effect of each factor, multiple correlation and regression methods must be applied. The SQC approach to multiple regression and correlation allows dominant factors to be located when 15 or less test packs are available. Using the SQC approach it is possible to work with small correlation matrices and to isolate dominant factors without an excessive loss of degrees of freedom. The method is illustrated on a typical set of shelf life data involving seven independent factors and 13 test packs.

The following conclusions were drawn from the SQC approach to this study:

1. Of the seven product and container factors studied over these 13 test packs of canned tomatoes, only four were found to be influential in relation to shelf life: Container factors A, B, C, and D. The remaining factors either covered too small a range of values in this study or they actually did not influence the shelf life of canned tomatoes. The four container factors extracted 99% of the available shelf life information in this study.
2. Shelf life limitations were determined for canned tomatoes based on the regression equation using the four dominant factors.
3. The best combinations of Container factors B and D were chosen to produce a long shelf life for canned tomatoes. These combinations were chosen with factors A and C eliminated from the data. Since the curvilinear function of D was apparent even in the presence of factors A and C, the combinations of B and D chosen with A and C eliminated from the data would be valid in the presence of these concomitant factors.

An integral part of the SQC approach is the use of a three dimensional plotting system to indicate relationships between the shelf life and the various product and container factors. When curvilinear relationships are indicated, the correlation surfaces may be investigated to obtain factor combinations producing a long shelf life. Concomitant factors may be eliminated while sets of two factors are allowed to vary in relation to shelf life. Three dimensional diagrams or models may be constructed to illustrate the relationship of the dominant factors to shelf life.

Although the method is illustrated with data accumulated in our container research laboratories, this SQC approach to multiple correlation and regression need not be confined solely to container studies. This multiple correlation method is particularly applicable to multifactor problems when only a small number of experimental units (15 or less) are available for study.

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Further Studies on the Preservation of Beef with Chlortetracycline [a, b]

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SINCE THE SUCCESSFUL use of chlortetracycline as a preservative of fresh beef was reported from this laboratory *(4, 9)*, this antibiotic has been studied rather extensively in beef both in the laboratory and in field trials. It has also been in limited commercial use in certain foreign countries *(2, 3)*. Its effectiveness has been established on ground beef, dressed-out carcasses, and on whole carcasses.

Antibiotic sensitivity studies on bacteria isolated from lymph nodes, bone marrow, and muscle tissue of 23 freshly slaughtered beef cattle *(7)* showed that about 12% of these organisms were resistant to chlortetracycline *(4)*. Resistant organisms represented the following five genera: *Streptococcus, Escherichia, Proteus, Alcaligenes,* and *Aerobacter*. If the constant or near constant occurrence of these resistant forms in beef is assumed, one might possibly expect on this basis that a comparable percentage of fresh beef preserved by chlortetracycline would actually spoil due to the overgrowth of the CTC-resistant flora. However, this spoilage has not been observed *(3)*. It has not occurred in experimentally infused beef in our laboratory, and one of the authors (F.E.D.) has failed to see it where the antibiotic has been used extensively in field trials conducted in warm countries.

A phenomenon that might explain why more failures of the antibiotic have not been observed was reported recently from this laboratory *(5, 6)*. The one bacterial species most frequently isolated from the deep tissues of beef that had been treated with chlortetracycline and allowed to spoil at room temperature was *Proteus vulgaris (5)*. Some strains of this organism that were resistant to chlortetracycline *in vitro* (50 to 100 p.p.m. were required to inhibit growth for 18 hours) were actually inhibited in beef by as little as 3 p.p.m. for 24–48 hours. Some strains of several other genera also behaved in a similar manner.

This report deals with further studies on chlortetracycline-resistant bacteria commonly found in meats in an effort to further understand why their growth should be inhibited in beef by low concentrations of the antibiotic. Other antibiotics were also tested for their ability to act in a similar manner. The relation between initial numbers of bacteria in meat and the growth inhibition by chlortetracycline has been studied. Also additional resistant strains of several genera have been studied in the same manner as previously described *(5, 6)*.

EXPERIMENTAL METHODS

Most of the cultures used in this study were isolated from the deep tissues of beef that was allowed to spoil at room temperature *(5)*. Those designated by O.S.U. numbers are stock cultures in the Department of Bacteriology of The Ohio State University. All were maintained in cooked meat medium (Difco).

Fresh beef, usually top or bottom round, was obtained immediately after slaughter and samples weighing 20 g. were removed as already described *(5)*. Samples were both inoculated and infused with needle and syringe. Number of organisms inoculated per gram was always determined by standard plate count using heart infusion agar (Difco). Samples were incubated at 28° C. Viable counts were determined by blending an entire sample and plating an aliquot. Buffered distilled water was used both as blending and dilution water.

As a rapid method to ascertain whether an *in vitro*-resistant organism was sensitive to chlortetracycline in beef, a 0.5% proteose-peptone medium was used *(6)*. The sensitivity of the organisms in this medium was found to correspond well with their sensitivity to the antibiotic in beef. The tubes were inoculated with approximately 20,000 organisms per ml.

To determine the minimal inhibitory concentration (MIC) of the antibiotics, doubling dilutions of the antibiotics were made in tryptose phosphate broth. Eighteen-hour-old cultures of test organisms were diluted 1: 100 in tryptose phosphate broth and 0.05 ml. added to 1 ml. of the above diluted antibiotic. Tubes were incubated at 37° C. and turbidity was read at 18 hours. Minimum inhibitory concentration is defined as the lowest concentration of antibiotic that completely inhibits growth of the organisms as determined turbidimetrically.

RESULTS

To be certain that organisms under study were actually chlortetracycline-resistant ones, minimal inhibtory concentration of chlortetracycline was determined against several typical bacterial isolates from spoiled beef at the pH of fresh beef on two different media. Results are shown in Table 1. Although minimal inhibitory concentrations were on the whole lower at the lower pH value, the 6 isolates (4 *Proteus*, one *Micrococcus*, and one *Escherichia*) were all resistant when minimal inhibitory concentrations were determined in tryptose phosphate broth and brain heart infusion broth at pH 5.6 and 7.3, and on tryptose phosphate agar at pH 5.6 and 7.3. Welch *(10)* has pointed out that organisms with MIC's of the tetracyclines above 10 should be considered resistant. These organisms were also resistant by the sensitivity disc method.

The minimal inhibitory concentration of chlortetracycline,

[a] Published with the approval of the Associate Director, The Ohio Agricultural Experiment Station, as Journal Article No. 54–57.

[b] Presented before the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

TABLE 1

The influence of pH and type of medium upon the minimal inhibitory concentration of chlortetracycline for some meat isolates

	pH	Tryptose phosphate broth		Tryptose phosphate agar		Brain heart infusion broth		Chlortetracycline discs
		7.3	5.6	7.3	5.6	7.4	5.6	
		p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	
P. vulgaris		50	25	50	25	25	12.5	Resistant
P. vulgaris		100	50	100	50	50	..	Resistant
P. morganii		100	25	50	50	50	25	Resistant
P. mirabilis		200	50	400	100	100	100	Resistant
Micrococcus sp.		200	25	50	..	100	..	Resistant
Escherichia sp.		300	200	100	200	100	100	Resistant

oxytetracycline, tetracycline, penicillin G, chloramphenicol, and streptomycin was determined against 3 *Proteus*, 2 *Pseudomonas*, and one *Escherichia* species in tryptose phosphate broth and is compared in Table 2. Minimal inhibitory concentrations of oxytetracycline and tetracycline against the organisms were usually a little lower than that of chlortetracycline, although chlortetracycline was a little more effective in beef as will be seen later. The *Pseudomonas* species were quite resistant to penicillin. One strain of *P. vulgaris* was sensitive to both chloramphenicol and streptomycin. *Ps. aeruginosa* was sensitive to streptomycin, and the species of *Escherichia* was sensitive to chloramphenicol.

Figure 1 shows a comparison of the effectiveness in beef of chlortetracycline, oxytetracycline, and streptomycin against a strain of *P. vulgaris* that had a minimal inhibitory concentration (for each antibiotic) of 50 in nutrient broth. Streptomycin was ineffective in inhibiting growth of the organism. These samples soured at the same time as the control, in 48 hours. Both chlortetracycline and oxytetracycline were effective. Oxytetracycline samples were sour in 72 hours while chlortetracycline samples did not sour until 96 hours. The 10 p.p.m. chlortetracycline brought about a greater reduction in the numbers of organisms at 24 hours than did oxytetracycline. However, the inhibition of the organisms was in effect slightly longer with oxytetracycline than with chlortetracycline.

In Figure 2 chlortetracycline and chloramphenicol are compared against a strain of *Ps. aeruginosa* (OSU 249) in beef. Fifty p.p.m. of each antibiotic alone were required to inhibit this organism in tryptose phosphate broth for 18 hours, but 5 p.p.m. chlortetracycline were much more effective than 5 p.p.m. chloramphenicol in beef. The low concentration of chlortetracycline in beef was always seen to be more effective against *Pseudomonas* species than against *Proteus*.

In another experiment the effectiveness of chlortetracycline, tetracycline, chloramphenicol, streptomycin, and penicillin is compared against a strain of *P. vulgaris* in beef. Concentrations of the antibiotics used here are all equal to one-fifth the minimal inhibitory concentration with the exception of chloramphenicol whose concentration was almost one-half the minimal inhibitory concentration as determined in broth. Again, only tetracyclines at this concentration were effective, with chlortetracycline being a little more effective than tetracycline.

In order to get some idea as to the range of effectiveness of chlortetracycline against resistant strains of some spoilage organisms in beef, a group of organisms were selected more or less randomly from our collection of meat isolates and from a stock collection. Most of these bacteria represent some of the most frequently found on meats that are resistant to chlortetracycline *in vitro*.

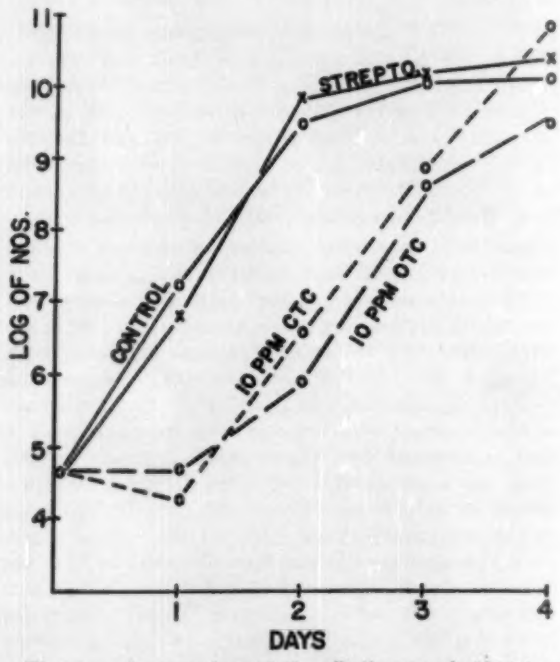

Figure 1. A comparison of the effectiveness of chlortetracycline (CTC), oxytetracycline (OTC), and streptomycin against P. vulgaris (minimal inhibitory concentration 50) in beef. The log of nos. represents numbers per gram of beef.

Table 3 shows the list of organisms, their minimal inhibitory concentrations, and probable number of strains that would be affected by 5 p.p.m. chlortetracycline in beef. Of the 39 strains tested 27 were inhibited (70%). Of these 39 organisms, 27

TABLE 2

The minimal inhibitory concentration in tryptose phosphate broth of several antibiotics against some chlortetracycline-resistant strains of bacteria

	Chlortetracycline	Oxytetracycline	Tetracycline	Pen. G	Chloramphenicol	Streptomycin
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
P. vulgaris	50	50	25	125	12.5	50
P. vulgaris	100	100	25	32	0.25	0.25
P. morganii	100	100	50	64	25	400
P. mirabilis	200	100	100	..	12.5	25
Ps. aeruginosa OSU 249	50	12.5	12.5	>1000	50	6.25
Ps. fluorescens OSU 197	50	12.5	12.5	>1000	50	12.5
Escherichia sp.	300	25	12.5	64	6.25	100

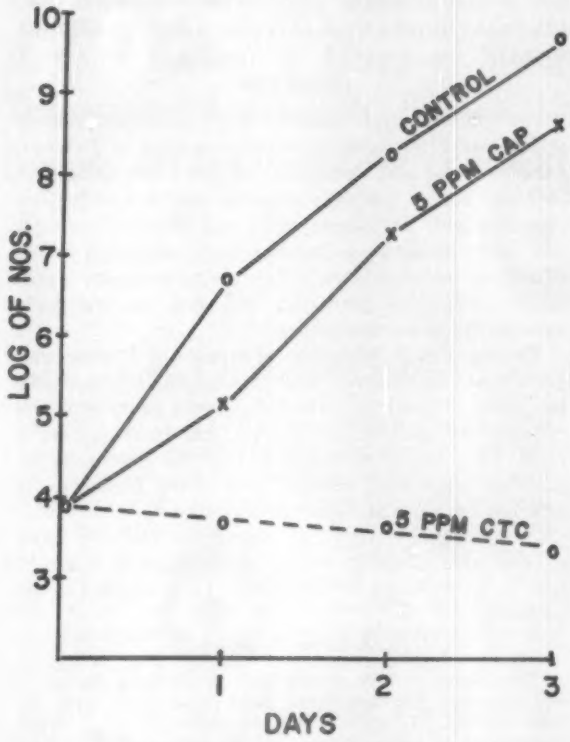

Figure 2. A comparison of the effectiveness of chlortetracycline (CTC) and chloramphenicol (CAP) against Ps. aeruginosa (minimal inhibitory concentration 50) in beef. The log of nos. represents numbers per gram of beef.

are strains of *Proteus*, 6 of *Pseudomonas*, 3 of *Serratia*, 2 of *Micrococcus*, and one of *Aerobacter*. Most strains of *P. vulgaris* were inhibited, whereas most strains of *P. mirabilis* and all strains of *P. morganii* and *P. rettgeri* were not inhibited. All 6 strains of *Pseudomonas* were inhibited. The 2 strains of *Micrococcus pyogenes* var. *aureus*, obtained from Dr. C. F. Niven, Jr., American Meat Institute Foundation, were described as being resistant to oxytetracycline and as being good food poisoning strains. The strain with a minimal inhibitory concentration of 50 was inhibited whereas the more resistant strain (MIC 200) was not.

Data in Table 3 were obtained using 0.5% proteose-peptone broth. Preliminary experiments showed that organisms which are inhibited in this medium for at least 24 hours by 5 p.p.m.

TABLE 3

The effect of 5 p.p.m. chlortetracycline on chlortetracycline-resistant organisms in 0.5% proteose-peptone broth

	Range of minimal inhibitory concentration in nutrient broth	Number of strains		
		Total	Affected	Unaffected
P. vulgaris	50–100	13	12	1
P. vulgaris	12.5	3	3	..
P. morganii	100–200	3	..	3
P. mirabilis	200–200	6	2	4
P. rettgeri	50	2	..	2
Ps. aeruginosa	25–50	4	4	..
Ps. fluorescens	50	2	2	..
A. aerogenes	25	1	1	..
Serratia spp.	12.5–25	3	2	1
M. aureus	50	1	1	..
M. aureus	200	1	..	1

chlortetracycline would also be inhibited in beef in a similar manner with inocula of less than 50,000 per gram.

In Table 4 data are presented to show the effect of size of inoculum upon the inhibition of a resistant strain of *Proteus* (MIC 50) by chlortetracycline in beef. The table shows that marked inhibition occurred within 24 hours with inocula up to 47,000 per g. Although some inhibition occurred with inocula of 65,000, 95,000, and 130,000 organisms per g., it was not as marked as with the smaller inocula. The amount of inhibition or the degree of effectiveness of chlortetracycline in

TABLE 4

Effect of size of inoculum upon the inhibition of P. vulgaris by chlortetracycline in beef

Inoculum	Thousands of bacteria in 24 hours/gram	
	Control	5 p.p.m. chlortetracycline
1.8	1.1	0.7
22	2,700	39
29	2,200	11
39	1,000	44
47	18,000	19 (10 p.p.m.)
65	20,000	1,800
95	230	40
130	70,000	15,000

beef differs slightly from animal to animal. In one instance marked inhibition was noted at 24 hours with an inoculum of *P. vulgaris* of 800,000 per gram. In general, however, inocula of this strain of *P. vulgaris* over 150,000 per g. were not inhibited significantly by 5 p.p.m. chlortetracycline. Data in Table 4, therefore, are representative of typical experiments.

Total bacterial counts of over 50,000 per g. on the deep muscle tissue of freshly slaughtered beef have been seen only very rarely.

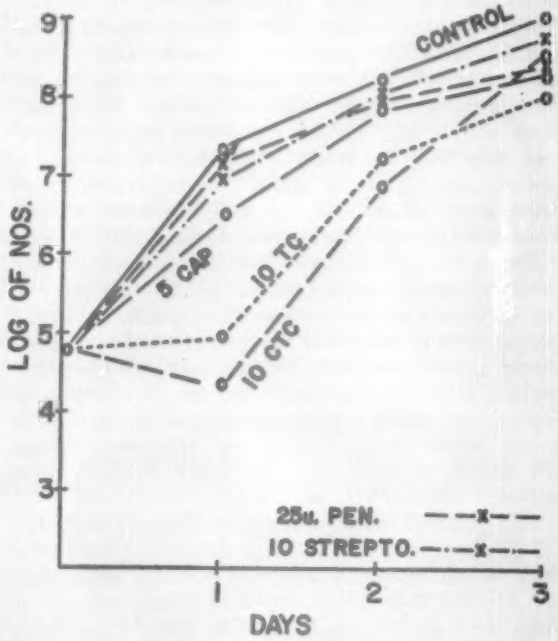

Figure 3. A comparison of the effectiveness of chlortetracycline (CTC), tetracycline (TC), streptomycin, chloramphenicol (CAP), and penicillin G against a strain of P. vulgaris (minimal inhibitory concentration 50) in beef. The log of nos. represents numbers per gram of beef.

DISCUSSION

It is clear that the usual *in vitro* sensitivity testing methods are not reliable indices as to how effective an antibiotic is against the same organisms in meat. Organisms described in the foregoing as being resistant to chlortetracycline were shown to be so by more than one *in vitro* technique. When the organisms were tested in meat a large percentage of them were found to be sensitive to the antibiotic.

An hypothesis was advanced earlier to explain why this phenomenon occurs *(5, 6)*. Briefly, the multivalent ions (both cations and anions) that are available in beef are probably so few that there are just enough to enable the bacteria to grow. Since the tetracycline antibiotics have been shown to be capable of acting as chelating agents *(8)*, it is possible that chlortetracycline and the other tetracyclines compete with the organisms for essential ions. In support of this hypothesis is the fact that the chlortetracycline inhibition of resistant organisms in beef can be reversed by tungstate, molybdate, silicate, borate, magnesium, calcium, strontium, barium, and maganous ions *(6)*. The ions will also reverse the inhibition in 0.5% proteose-peptone broth.

Although poultry has not been worked with in this connection, it is quite possible that a similar if not the same mechanism comes into play in the preservation of this product by the tetracyclines. Many authors have shown that very low concentrations of the antibiotics are taken up into the flesh when dipped in low concentration dipping solutions. Even the concentration on the surface is low. Ayres *et al. (1)* found less than 2 p.p.m. chlortetracycline on the surface of birds immediately after dipping in a 10 p.p.m. solution. Only 0.7 p.p.m. was demonstrable 1 hour later. The antibiotics were effective, however, in extending the holding time despite the fact that a very large portion of the flora consists of pseudomonads, organisms that are generally resistant to these antibiotics. As previously stated chlortetracycline was much more effective in low concentrations against *Pseudomonas* spp. than against *Proteus* spp. in beef.

The ability of the tetracycline antibiotics to disturb the ionic balance could possibly account for the success of these agents over most other antibiotics in the preservation of meats. If the above stated hypothesis should prove to be true, this property of the tetracyclines might be responsible for the effectiveness of these agents against tetracycline-resistant bacteria in meats. Most other antibiotics lack this property and are therefore ineffective, as many workers have shown.

With respect to the bacterial flora of beef, two things should be pointed out: the mesophilic rather than the psychrophilic flora, and the deep rather than the surface flora have been of primary interest in these studies. Organisms listed in Table 3 are fairly representative of the deep flora that predominated during deep spoilage of beef held at room temperature in this laboratory *(5)*. Under refrigerated conditions one usually finds, of course, a slightly different flora.

SUMMARY

The phenomenon wherein low concentrations of chlortetracycline inhibits resistant strains of *Proteus*, *Pseudomonas*, and strains of certain other genera in beef but not in complete nutrient media was further characterized. Oxytetracycline and tetracycline were also found to act in a similar manner although not as effectively as chlortetracycline. Streptomycin, chloramphenicol, and penicillin did not act similarly against the same organisms.

The significant inhibition of strains of *Proteus vulgaris* could be observed with inocula as high as 65,000 per gram. Inocula of over 150,000 per gram were not consistently inhibited by 5 p.p.m. chlortetracycline in beef. Of a group of resistant bacteria commonly associated with beef around 70% were found to be affected by 5 p.p.m. chlortetracycline.

It is suggested that the effectiveness of the tetracycline antibiotics in retarding spoilage in meats is due to their ability to disturb the ionic balance in the product.

Acknowledgments

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Factors Affecting Quality of Prepackaged Meat[a]

II. Color Studies. B. Effects of Storage Time, Storage Temperature, Antioxidants, Bacteria, Light, Freezing and Fat Upon Color of Product[b]

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EFFECT OF STORAGE TIME[c]

THE RATIOS OF THE SHORT SYSTEM weighted color ratings to the long system weighted color ratings of meat in packages of each type[d] were calculated. A ratio greater than 1 (short to long) means that a package type was better in maintaining good color during the first 2 or 3 days than during the later days of a storage period of either 12 or 7 days. A ratio of less than 1 means that the package type was better in maintaining meat color under the rating distribution of the long term system than under that of the short term system.

On the 12-day basis of reckoning, all samples had ratios greater than 1 except

a. lean and fat ground pork in film 17,
b. lean ground pork in cans,
c. lean and fat cuts of pork in cans,
d. lean ground lamb in film 6w, and
e. lean cuts of lamb in film 6d.

On the 7-day basis of reckoning, all samples had ratios greater than 1 except items b, c, d, and e, above. The interpretation of these results is that pork in cans and certain categories of lamb samples in films 6d and 6w had color after the third day of storage as good as or better than that during the first three days.

The low ratio values of items d and e, above, seem completely inconsistent with all other results obtained with films 6d and 6w, since, with the exception of No. 10 film (polyethylene), the highest average, as well as the highest maximum ratio values were obtained on samples in films 6d and 6w, indicating that meat packaged in these films decreased in redness relatively more between three and six days than meat in the other packages. There was practically no difference between the values of ratios obtained for samples in cans and those for samples in film 15.

In almost all instances, the ratio values for the 7-day period are higher than those for the 12-day period. Due to the patterns of distribution of the weighting factors used, in the few instances in which the short/long ratio values are higher for the 12-day period than for the 7-day period, these results indicate that the average color rating for the 8th and 9th days was greater than the average color rating for the 5th, 6th, and 7th days.

Neglecting the effects of difference between the bases of evaluation and of variations in character of meat in the samples, the average short/long ratios for the various package types were as shown in Table 1. In interpreting these data, it should be borne in mind that low ratio value indicates higher rating for color after the third day of storage.

TEMPERATURE

The effect of temperature on the color change of meat was determined for both unpackaged samples (atmospheric pressure) and for samples sealed under 27 inches of vacuum in cans. Three widely differing storage temperatures were used, namely, 34° F., 54° F., and 85° F. The unpackaged samples were stored in the dark, and maintained at close to 100% relative humidity in desiccators. The rate of initial darkening of the unpackaged samples increased as the storage temperature increased. Samples stored at 85° F. lost redness very rapidly while samples stored at 54° F.

[a] A report of work conducted by contract with the Bureau of Animal Industry, U. S. Department of Agriculture, with funds provided under the Research and Marketing Act.

[b] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Departments of Food Technology and Animal Husbandry, New Brunswick, N. J.

[c] For a definition of the short and the long storage periods, the reader is referred to section IIA of this report, published in the October issue of *Food Technology*.

[d] The following is the legend of codes representing the various package types used in this investigation:

Code Number	*Packaging Material*
2	Can
3	Unpackaged
4a	Vinylidene copolymer (Cry-O-Vac)
6	MSAT86 cellophane, coated both sides
6a	MSAT80 cellophane, coated side inside
6d[1]	MSAT80 cellophane, coated side outside
6w[1]	MSAT80 cellophane, coated side outside (wrapped)
8[2]	Cellulose acetate P-912
10[1]	Polyethylene
15	Cellophane-pliofilm laminate, pliofilm inside
16	Cellophane-polyethylene laminate, polyethylene inside
17	Cellulose acetate-pliofilm laminate, pliofilm inside
20	Trithene (wrapped)

[1] "Hand" made in the laboratory.
[2] "Hand" made by Celanese Corporation; all other film packages except No. 20 were "factory" made by Standard Packaging Corporation.

TABLE 1

Ratio of weighted color ratings obtained by the short system to the weighted color ratings of meat in the same package type obtained by the long system on both the 7-day and the 12-day basis

Package No.	No. of Runs Involved	Species of Meat	Average Short/Long Ratio
2	9	Beef	1.05
4	1	"	1.10
6	1	"	1.01
8	1	"	1.08
15	6	"	1.045
16	1	"	1.09
2'	14	Lamb	1.045
6a	3	"	1.09
6d	5	"	1.11
6w	3	"	1.075
10	3	"	1.34
15	9	"	1.05
17	1	"	1.01
2	9	Pork	0.995
6d	2	"	1.07
6w	1	"	1.17
15	7	"	1.03
17	1	"	0.895

lost redness at a somewhat lower rate. Unpackaged samples stored at 34° F. increased in redness during the first day of storage and thereafter gradually decreased in redness for 20 days. Samples stored at 85° F. in addition to having a foul odor, had greenish discolored areas in 2 days and were discarded after 3 days because of advanced decomposition. The samples stored at 54° F., after an initial decrease in redness for 3 days, tended to increase in redness for the remainder of the storage period. However, the samples had an undesirable odor after 6 days of storage. Part of the pigment responsible for the increase in redness might have been pigments produced by microbial growth. Figure 1 shows the effect of temperature on the color of unpackaged ground beef samples.

The rate of initial darkening of the samples packaged under 26 inches of vacuum in cans increased as the storage temperature increased (see Figure 2). In one day the redness value of the "canned" samples

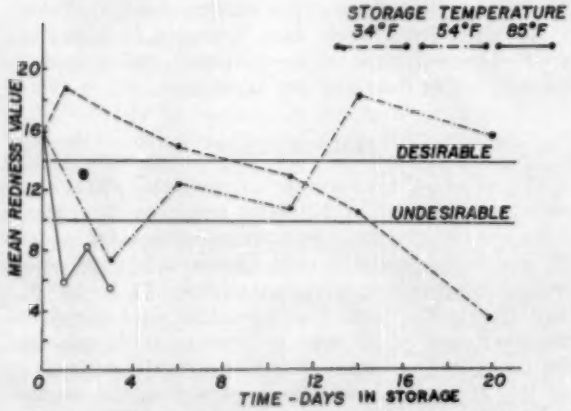

Figure 1. Redness changes of unpackaged ground beef lean samples stored at 34° F., 54° F. and 85° F.
(Top of samples)

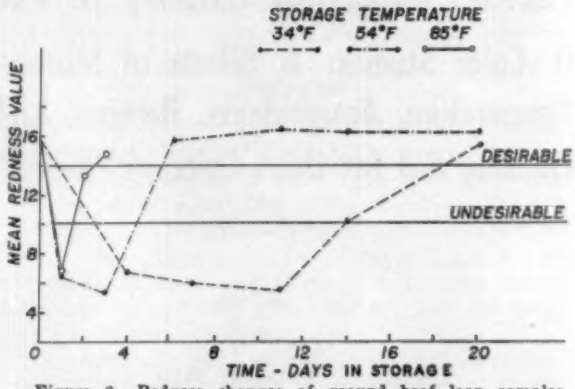

Figure 2. Redness changes of ground beef lean samples packaged in cans under vacuum and stored at 34° F., 54° F. and 85° F.
(Top of samples)

stored at 85° F. and 54° F. dropped lower than the redness value of the samples stored at 34° F. The "canned" samples stored at 85° F. then rapidly increased in redness until at 3 days their redness value approximately equalled the initial redness value. The samples stored at 54° F. returned to their initial redness value in 6 days. The "canned" samples stored at 34° F. both lost and regained redness more slowly. In these samples, redness decreased for 11 days before beginning to return. Between 11 and 20 days, redness increased to a value only slightly lower than on packaging day. The pattern of color change exhibited by the "canned" and unpackaged samples stored at 34° F., as shown in Figures 1 and 2, conforms to the pattern shown by meat stored at 34° F. in other runs. Higher temperatures, therefore, increased the rate of redness loss in samples stored at either atmospheric pressure or under vacuum. Vacuum storage at higher storage temperatures also shortened the time required for the subsequent return in redness. In one run, unpackaged samples stored under atmospheric pressure attained a redness value of greater magnitude than they had when packaged. This might be caused, at least partially, by microbial growth on the surface.

ANTIOXIDANTS

The method of treating the meat with the antioxidants, ascorbic acid and NDGA, are described in Section 1A, published in a previous issue of FOOD TECHNOLOGY.

The treatment of ground fat and lean samples of lamb with 0.05% NDGA was detrimental to the color of all samples except the samples packaged in cans and the lean samples packaged in film 10. In these lots, color of the treated samples was slightly better than that of nontreated samples.

In contrast with the samples of lamb treated with NDGA, all samples of ground lamb, lean or fat, benefited from treatment with 0.1% ascorbic acid. The fat samples benefited more than the lean samples. The samples packaged in film 15 were better than

similar samples packaged in film 10. These results are shown in Table 2, which in the second and third columns, gives the ratios of the ratings of the treated samples to the ratings of the corresponding untreated "canned" samples, on the 12-day basis. The column under short/long was calculated by taking the ratios of the ratings under the short system to the ratings under the long system of evaluation, without regard to their relationship to corresponding ratings of samples in cans.

Table 3 presents the ratios of the ratings on the 12-day basis of treated cut samples of beef to the

TABLE 2

Ratios of weighted color ratings for ground lamb treated with 0.1% ascorbic acid in films to those for corresponding untreated "canned" control samples (12-day basis), also ratios of the short system weighted color ratings to the long system weighted ratings

Sample	Short	Long	Short/Long
Film 10 (fat)	0.90	0.67	1.17
Film 10 (lean)	1.02	0.93	1.06
Film 15 (fat)	1.05	0.98	0.93
Film 15 (lean)	1.23	1.21	0.98

ratings of the corresponding untreated "canned" samples (columns 4 and 5) and the ratios of the ratings of samples under the short system to the ratings for the same samples under the long system of evaluation, without regard to their relationship to corresponding ratings of samples in cans (column 6).

The ratios of the weighted ratings for color of all samples treated with an antioxidant to the rating of similarly packaged but untreated samples are presented in Table 4. These data indicate that there was a slight improvement in the red color of the "canned" cuts of beef by all concentrations of ascorbic acid. The lean samples packaged in film 15 also showed a slight improvement when treated with 0.05 to 0.1 per cent ascorbic acid. The effect of ascorbic acid upon all other cut samples of beef was deleterious to the red color. This effect was especially true for

TABLE 3

Ratios of weighted color ratings for ascorbic acid treated cuts of beef in various packages to those for untreated "canned" control samples (12-day basis)

Type of Package		% Ascorbic Acid	Short	Long	Short/Long
Lean Beef	Canned	0.05%	1.04	1.05	0.98
	Canned	0.1%	1.07	1.06	0.99
	Canned	0.5%	1.08	1.17	0.94
	Film 15	0.05%	1.14	1.15	0.99
	Film 15	0.1%	1.11	1.11	0.99
	Film 15	0.5%	0.90	0.93	0.99
Fat Beef	Canned	0.05%	1.06	1.08	1.00
	Canned	0.1%	1.01	1.02	1.00
	Film 15	0.05%	1.17	0.99	0.99
	Film 15	0.1%	1.13	0.99	0.99

the samples treated with 0.5 per cent ascorbic acid which caused marked browning during churning. The effect of ascorbic acid in this concentration, therefore, occurred quickly after treatment with the antioxidant. Although there generally was a slight return of redness during storage, the overall effect of this concentration of ascorbic acid on color was detrimental.

ACHROMOBACTER

Fat, ground pork inoculated with *Achromobacter* was stored in cans, film 15, and film 6d. The method of inoculation is described in Part IV, covering the microbiological phase of the investigation. Negative values were obtained in both the short and the long systems of color evaluation for all non-inoculated samples, except the samples packaged in film 6d evaluated by the short system. Because of these negative ratings, which resulted from negative readings of a_{L^*} negative values would be obtained in the ratios of the ratings of the various samples to the ratings of the non-inoculated "canned" samples. To avoid the use of negative ratios, the sum of the weighted ratings of all the non-inoculated samples in Package Type 2 was algebraically subtracted from the sum of the weighted ratings of an equal number of samples of each of the other classes to obtain differences instead of ratios of rating values. These differences, all posi-

TABLE 4

Effect of Antioxidants

Ratio of weighted color rating of treated sample to the rating of a similarly packaged untreated sample (12-day basis)

Type of meat	Package	0.05% Ascorbic acid		0.1% Ascorbic acid		0.5% Ascorbic acid		0.05% NDGA	
		Short	Long	Short	Long	Short	Long	Short	Long
Ground lean lamb	Can			1.30	1.31			1.09	1.06
	Film 10			2.59	2.71			1.11	1.11
	Film 15			1.18	1.22			0.96	0.92
Ground fat lamb	Can			1.28	1.17			1.01	1.09
	Film 10			4.03	6.35			0.75	0.57
	Film 15			2.92	3.34			0.87	0.83
Cut lean beef	Can	1.04	1.05	1.07	1.06	1.08	1.17		
	Film 15	1.06	1.06	1.02	1.02	0.75	0.75		
	Film 15 (atm)[1]					0.65	0.65		
	Desiccator[2]					0.93	0.93		
Cut fat beef	Can	1.06	1.08	1.01	1.02				
	Film 15	0.96	0.96	0.92	0.92				

[1] Denotes sample packaged in film 15 sealed under atmospheric pressure.
[2] Sample packaged in desiccator sealed under 5 cm. of absolute pressure of air.

tive, are presented in Table 5. The higher the value, the greater is the superiority of color rating over that of the Type 2 non-inoculated samples.

Fat ground fresh ham samples benefited considerably in color retention when treated with *Achromobacter sp.*

The contour of the time-color curve for inoculated fat samples of ground lamb was similar to the curves of non-inoculated samples, except that the return was more pronounced. The return began on the second and extended through the sixth day of storage which is earlier than usual. The normal beginning of color return for fat samples of lamb was from the fourth to the sixth day of storage.

Inoculation of ground fat pork samples with *Achromobacter* produced a better color than was obtained in non-inoculated samples for the first 10 days of storage. After this time, the non-inoculated samples were higher in redness than the inoculated samples. Fat samples in cans inoculated with *Achromobacter*—returned to their original color in 7 days and then decreased in redness, whereas the non-inoculated samples returned to the original color in 14 days. This indicates that this organism hastens the color return cycle.

TABLE 5

Algebraic differences in total rating values for color between inoculated and non-inoculated samples in packaged types 2, 6d, and 15 and the non-inoculated samples in package type 2 (12-day basis)

Sample	Short	Long
Can (Type 2) non-inoculated	0	0
Can (Type 2) inoculated	557.7	651.5
Film 6d — non-inoculated	269.5	246.0
Film 6d — inoculated	319.7	390.3
Film 15 — non-inoculated	116.8	67.2
Film 15 — inoculated	316.7	378.4

LIGHT VS. DARK STORAGE

The effect of light vs. dark storage was studied on pork, lean and fat, and cured ham. The experiments are described in Section IA. Table 6 shows the ratios of the weighted ratings for color of samples stored in the light to the ratings of similarly packaged samples stored in the dark. The values for fresh pork are averages obtained from Runs Y, Z, AA, and BB. The values for the cured meat are the ratios of single samples in Run KK.

By storing the samples in the light the red color of fresh pork was apparently slightly improved. The effect of the light upon the color of cured meat was deleterious except in the case of cuts of ham in film 15 during a long storage period.

Figure 3 shows the effect of light vs. dark storage on cured ham packaged in packages of types 2, 15, 6d, and 6w.

Table 7 presents the ratios of the ratings of the samples packaged in films to the ratings of the corresponding "canned" samples.

TABLE 6

Ratios of weighted color readings of samples stored in the light to those of similarly packaged samples stored in the dark (12-day basis)

Sample			Short	Long
Cut	Fresh Pork lean	— Film 15	1.06	1.11
Cut	Fresh Pork fat	— Film 15	1.11	1.12
Cut	Cured Ham	— Film 15	0.90	1.03
Cut	Cured Ham	— Film 6d	0.69	0.67
Cut	Cured Ham	— Film 6w	0.70	0.65
Ground	Cured Ham	— Film 15	0.93	0.95
Ground	Cured Ham	— Film 6d	0.81	0.77
Ground	Cured Ham	— Film 6w	0.76	0.74

As part of the test to determine the effects of light and of vacuum upon the color of cured ham sealed in pouches of film 15, a study was made of the reading of color of the samples without removing them from the film pouch. The results which are presented in detail in a thesis,* indicated that the color of meat, as registered by the Hunter Meter, was essentially the same when the meat was covered with a single cellophane-pliofilm laminate film as when the meat was not covered. This test was discussed in Section II-A, and will be further discussed in Section II-C.

FAT IN CONTACT WITH THE LEAN SURFACES

In several of the runs in the project, it was noted that fat samples of ground meat sealed under vacuum in cans, returned in redness sooner than the lean samples. Therefore, the effect of a layer of fat covering the lean surface of cut samples upon the color of the lean was studied. Cut samples were packaged under vacuum in cans and in film 15. One-half of the top and bottom surfaces was covered with a layer of fat and the other half of the surfaces was left exposed within the packages. In the can, the lean under the layer of fat was slightly higher in redness than the exposed lean surfaces. The lean surfaces under the layer of fat in film 15 were also higher in redness

*Bressler, Lawrence. Color Changes During Storage of Prepackaged Cured Ham Sealed in Cellophane-pliofilm Laminate Containers While Surrounded by Air at Various Pressures. Rutgers Univ., May, 1954.

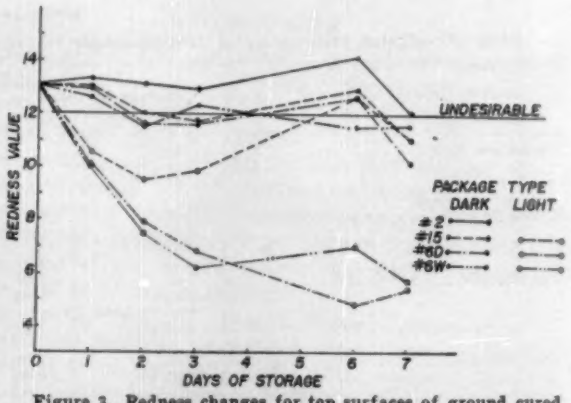

Figure 3. Redness changes for top surfaces of ground cured ham samples in light and dark storage.

TABLE 7

Ratios of weighted color readings of samples of cured ham stored in the light and in the dark to those of the corresponding "canned" control sample (12-day basis)

Sample	Storage	Short	Long
Cut — film 6d	Dark	0.92	0.92
Cut — film 6d	Light	0.64	0.62
Ground — film 6d	Dark	0.88	0.89
Ground — film 6d	Light	0.72	0.69
Cut — film 6w	Dark	0.86	0.86
Cut — film 6w	Light	0.70	0.56
Ground — film 6w	Dark	0.91	0.90
Ground — film 6w	Light	0.70	0.67
Cut — film 15	Dark	0.92	0.86
Cut — film 15	Light	0.84	0.89
Ground — film 15	Dark	0.93	0.93
Ground — film 15	Light	0.86	0.86

Note: Storage period was 7 days.

after 4 days of storage than exposed surfaces although between 1 and 4 days, the fat covered surfaces were lower in redness than the exposed surfaces.

DISCUSSION

Storage temperature. The increase in the rate of initial discoloration caused by increasing the storage temperature can be explained by known effects of temperature on the oxyhemoglobin dissociation curve and the depth of oxygen penetration into the meat.[1] Brooks *(2)* stated that at 30° C. oxyhemoglobin dissociates rapidly to reduced hemoglobin as the oxygen pressure drops below 80 mm. Roughton *et al. (8)* showed that the effect of temperature on the oxygen dissociation curve of oxyhemoglobin was an alteration of scale rather than of shape. At 0° C. oxyhemoglobin dissociates to hemoglobin and oxygen as the oxygen pressure is decreased below 20 mm. of mercury. At this temperature the rate of methemoglobin formation is maximal at about 4 mm. of oxygen *(3)*, while at 30° C., the maximum rate of methemoglobin formation is at 20 mm. *(7)*. It is apparent that increasing the temperature of the meat causes oxyhemoglobin to be more easily dissociated to hemoglobin at a constant oxygen pressure. Since methemoglobin formation is favored by hemoglobin formation *(5)*, one would expect an increased rate of darkening (methemoglobin formation) at higher temperatures. Brooks *(1)* has shown that an increase in temperature also decreases the depth of oxygen penetration into the tissues. Since methemoglobin is formed most rapidly at the inner surface of the oxyhemoglobin layer, a decrease in oxygen penetration allows rapid methemoglobin formation to occur near the surface of the meat, which in turn causes loss of apparent redness.

Antioxidants. The results obtained with ascorbic acid are in agreement with those of Watts and Lehman *(9)* who stated that ascorbate may be useful in preserving the red color when appplied in small concentrations to the surface of refrigerated meats.

The improvement in color due to the addition of ascorbic acid was greater during the early part of the storage period than it was toward the end (2 weeks). When either 0.05 or 0.1% ascorbic acid was added to cuts of beef, there was very little difference in color between these cuts and control samples. At the 0.5% level ascorbic acid was detrimental to the color of cuts of beef. This relatively high concentration of ascorbic acid may have so great a demand for oxygen as to cause the removal of oxygen from the oxyhemoglobin on the surfaces of the meat. The formation of methemoglobin would therefore be favored. However, ascorbic acid in larger amounts may have beneficial effects upon ground beef because the antioxidant is uniformly distributed throughout the ground meat, instead of being concentrated at the surface as it is on treated cut samples.

The effect of 0.05% nordihydroguaiaretic acid was not consistently toward either the improvement or the degradation of the meat color. The difference between treated and untreated samples was not significant in most cases. However, Kraft and Vanderstock *(6)* found that nordihydroguaiaretic acid in 0.01% concentration was effective in inhibiting color changes of round steak when brushed onto the surface in a coconut oil carrier. Since the concentration of antioxidants on the color of meat is quite critical, it is possible that lower concentrations of NDGA would have produced a different effect on the color of ground meat than is reported here.

Achromobacter. Halleck *(4)*, in his report on the microbiological phase of this investigation, portrays a significant correlation between the color of the lean meat and the concentration of *Achromobacter* and Lactobacillus organisms on the meat. Meat in cans (package type 2) changed in color from red to brown during the first two days after packaging, which was a lag period in the growth of these microorganisms, and changed back to a red color during the period, in which strong bacterial growth was taking place. Halleck noted that complete return of the red color usually was evident at the time that a bacterial concentration maximum from adventitious contamination occurred. Data on samples which were inoculated with *Achromobacter* tended to strengthen the deduction. Mathematical confirmation of the correlation was presented; also, citations from the literature offering possible explanations of indicated effects by bacteria upon meat color. These explanations center upon assumed influences of the microorganisms upon oxidation-reduction potentials in the meat.

Halleck reasoned that the red-brown color change in the can packaged meat was a physico-chemical change resulting from the depletion of oxygen from the oxymyoglobin by respiratory enzymes of the meat tissue and the bacterial flora. It would seem that the mechanical maintenance of vacuum and the action of bacteria were both instrumental in producing the color change cycle which typified the results obtained in this project.

[1] It seems to be fairly well established that myoglobin compounds are the chief coloring constituents of lean muscle and that the results of experimental work done with hemoglobin may be applied to myoglobin. Many authors do not differentiate between blood and muscle hemoglobin, (myoglobin). In the discussion which follows in Section IIB, hemoglobin will be used to apply to both blood and muscle hemoglobin.

Figure 4 shows a typical relationship between the bacterial counts and the a_L color values of can packaged fat ground pork stored at 40°–44° F. These results are indicative of the correlations shown between the rate of increase in a_L values and the rate of increase in bacterial growth. Bacterial growth may be partially responsible for the return in red color of the meat.

Light. Ramsbottom, Goeser, and Shultz *(8)* have shown that the rate of discoloration of cured meat is proportional to the intensity of light. The light seems to catalyze the oxidation of nitric-oxide hemoglobin and nitric-oxide hemochromogen in the presence of oxygen. In the absence of oxygen, light does not cause discoloration. The fact that cured meat stored in the light in film 15 discolored less than cured meat stored in the light in cellophane is probably due to the greater degree of impermeability to air of the former film. With less oxygen available, the discoloration was not as great in film 15 as when more oxygen was present.

Frozen meat. In several runs, meat was frozen for use in a later run. In comparison to fresh meat, the previously frozen and thawed meat was initially lower in redness value. The color of the bottom surfaces of meat which had been frozen before being thawed and packaged in cans was redder between 2 and 8 days than the bottom surfaces of meat which was not frozen and thawed before sealing in cans. The redness values of the top surfaces of samples which had been previously frozen or not frozen showed no such difference in color changes. Meat that was frozen before being thawed and stored in film 15 was lower in redness value during storage than samples that were not previously frozen before being stored in film 15.

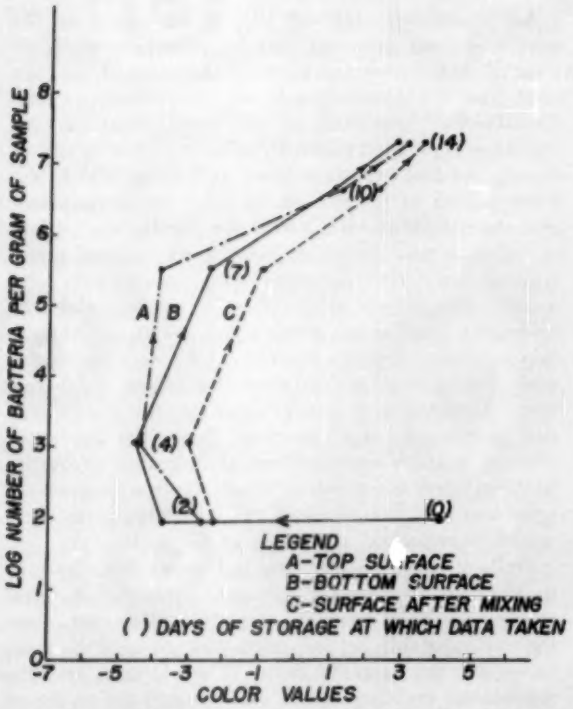

Figure 4. Relationship between bacterial counts and the a_L color values of can-packaged fat ground pork stored at 4–6.5° C. (40–44° F.).

SUMMARY

Storage time and temperature. The rates of change in color of unpackaged meat and of meat sealed in cans under vacuum increased as the storage temperature increased within the range of from 34° to 85° F. This applied both to loss of redness and change back to redness.

Antioxidants. Ascorbic acid in low concentrations (0.05 to 0.1%) usually improved the color of ground meat in all packaged types used. The improvement was greater early in a two week storage period than later in the storage period. The improvement in color due to the addition of ascorbic acid was greater in ground lean samples packaged in film 10 (polyethylene) than in samples packaged in film 15 (cellophane-pliofilm laminate). No apparent improvement in color was derived in treating cut samples with ascorbic acid. The addition of 0.5% ascorbic acid to cut samples was deleterious to the color of the meat.

The addition of ascorbic acid to ground lean and fat samples stored in cans under 27 inches of vacuum at 40° F. shortened the time required for the return in redness after initial discoloration by about three days.

NDGA (Nordihydroguaiaretic acid—0.05%), in general, caused no improvement in the meat color. With ground fat samples packaged in film 10 (polyethylene) and film 15 (cellophane-pliofilm laminate), there was a definite adverse effect due to the addition of this concentration of NDGA.

Achromobacter. The inoculation of ground fat pork samples with *Achromobacter*, improved the color of the meat in the can, film 6d (MSAT80, coated side outside), and film 15 (cellophane-pliofilm laminate). This improvement was restricted to the first ten days of storage, after which the non-inoculated samples were higher in redness.

With lamb, the organism shortened the time required for the return of redness by two days.

In the microbiological phase of this investigation, to be reported subsequently, the data indicated that the complete return of redness usually was evident at the time that the maximum bacterial growth occurred.

Light. Light was found to have little effect on the color of fresh meat. Storage of cured meat in the light resulted in loss of redness very quickly. This adverse effect of light on cured ham was less in samples packaged in film 15 (cellophane-pliofilm laminate) than it was in samples packaged in films 6d (MSAT80, pouch, coated side outside) and 6w (MSAT80, wrapped, coated side outside.)

Frozen meat. In several runs, meat was frozen for use in a later run. In comparison to fresh meat, the previously frozen and thawed meat was initially lower in redness value.

Fat. There is evidence that lean surfaces of samples in contact with a layer of fat were higher in redness after about one week of storage than the surface of the meat in contact with the packaging material. Between the first and fourth days of storage the surface covered with fat was lower in redness than the uncovered surface.

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Correlation Between Flavor and Number of Microorganisms Associated with Eviscerated Chicken Treated with Chlortetracycline[a, b]

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A review of the literature by Campbell and O'Brien *(4)* in 1955 on the use of antibiotics to prevent bacterial spoilage of fresh food revealed the extent and nature of the progress in this field during the previous 12 years. Since the bulk of the poultry sold in this country is fresh, there exists a serious problem of losses due to spoilage. Hence, the effective use of antibiotics to prolong the storage life of fresh chicken could result in substantial savings for the industry and also benefit the consumer, if the "fresh" flavor also is maintained.

Recently a number of investigators have reported that antibiotics have prolonged the storage life of fresh chicken *(1, 3, 5, 6, 7, 8, 9, 10)*. For example, Kohler, Miller, and Broquist *(6)* reported that whole eviscerated or cut-up chickens dipped in water containing Aureomycin and stored at 40° F. remained fresh for 7 to 14 days longer than the untreated controls. Ayres *et al. (1)* reported that at minimum concentrations (3 or 10 p.p.m.) chlortetracycline was the most effective of the 10 antibiotics tested for prolonging the storage life of birds stored at 40° F. Oxytetracycline was second in order of effectiveness and, at 30 p.p.m., these two tetracyclines were comparable. At present both chlortetracycline (CTC) and oxytetracycline (OTC) are permitted by the Food and Drug Administration for the preservation of poultry meat. The most beneficial results have been obtained when the antibiotic was used with the appropriate sanitary conditions on a "clean" product *(3)* and when the poultry was stored at temperatures as near 32° F. as possible *(7)*.

Previous investigators have been concerned mainly with the effectiveness of antibiotics in delaying the growth of microorganisms that cause spoilage and have used bacterial counts as their criterion for deter-

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mining "freshness" of the poultry. However, any increase in the storage of poultry or of any fresh food raises the question of the effect of this treatment on the organoleptic qualities of the product. One study that has evaluated the flavor of antibiotic treated poultry stored whole in ice for extended periods was reported recently by Dawson *et al. (5)*.

Since the maintenance of a "fresh" flavor may be dependent upon factors other than total bacterial count, the present studies were designed to determine the effect on flavor of extending the shelf life of cut-up, packaged broilers stored in a commercial, open, refrigerated case. Two types of packaging were evaluated. In addition, bacterial counts were made during storage to determine whether or not there was a correlation between flavor and number of micro-organisms found on untreated controls or on treated cut-up broilers.

PROCEDURE

This study consisted of a series of 6 experiments conducted from November to April to evaluate the bacterial and organoleptic qualities of cut-up, packaged broilers treated with: (1) no antibiotic, (2) Aureomycin* as prepared for the Aeronize process and (3) crystalline chlortetracycline. In the first 4 experiments, the broilers were packaged in Cryovac; for the last 2 experiments, LSAD-300 cellophane was used. In general, the procedure was similar for all 6 trials; i.e., the untreated and treated whole birds were covered with crushed ice in a wire-bound shipping box and stored in a walk-in refrigerated room (34° ± 2° F.). Each morning an untreated and a treated bird were removed from the ice, and bacteriological samples were taken. The chickens were cut-up, packaged and placed in a commercial, refrigerated display case (37° ± 5° F.) for 24 hours to 48 hours. After storage, bacteriological and subjective evaluations were made on these 2 samples and on a control that had been stored whole in the crushed ice.

Since there were no commercial plants processing broilers in central Iowa, all of the chickens (2–2½ lbs.) were obtained from a distributing plant in Nevada, Iowa. The chickens were killed, eviscerated and packed whole in ice in Arkansas on Monday and shipped to Nevada, Iowa. On Tuesday, the birds were delivered in wire-bound wooden boxes to the laboratory at Iowa State College. One-third of the total number of whole birds (24 obtained for each replicate were removed from the ice and immersed in a 10 p.p.m. solution of antibiotic at 50° F. for 30 minutes. In the 4 experiments in which the chickens were packaged in Cryovac, Aureomycin was used; for those birds wrapped in LSAD-300 cellophane, chlortetracycline was used.

After treatment with the antibiotic, the whole birds were covered with crushed ice, placed in the original box and stored in the walk-in refrigerator. At 24 or 48 hour intervals, one treated and one untreated bird were removed from the crushed ice, and bacterial samples were taken. Then the chickens were cut, packaged, and stored in an open display case. The method used for bacterial evaluations is the same as described by Ayres *et al. (1)* except plates were incubated at 75° ± 5° F.

For vacuum packaging, the cut-up broiler was placed on a molded fiber-board tray and inserted into a Cryovac bag. A vacuum was drawn and the bag sealed with a metal clip before immersing in hot water (204° F.) for 10 seconds. Birds packaged in LSAD-300 cellophane were cut-up, placed on a molded fiberboard tray, wrapped and heat sealed.

Packaged birds were stored in a commercial, open-type, refrigerated case (McCray, Model 17A7513) at 37° ± 5° F. for 24 hours except between the 4th and 6th day when they were stored for 48 hours.

After storage for 24 or 48 hours, chickens were removed from the display case, and bacterial counts were taken before cooking. For subjective evaluation, 3 samples were deep-fat fried: (1) an untreated control that had been stored whole in crushed ice, (2) an untreated control, that had been cut-up, packaged and stored (for 24 or 48 hours in an open display case) and (3) an antibiotic treated sample that also had been cut-up, packaged and stored (for 24 or 48 hours in an open display case).

Prior to cooking, the samples to be deep-fat fried were checked by 2 individuals for presence of any off-odor. If samples had any off-odor, they were not used.

The thigh, leg, and breast were prepared for cooking by dipping in milk and dredging in flour (1 part potato to 2 parts all-purpose flour). These pieces were fried in 5 pints of corn oil in an electric deep-fat fryer (Sunbeam, Model CF) at 365° F. for 10 minutes and served to a panel of 6 trained judges. Tenderness, juiciness, flavor of meat and of skin and off-flavor were scored on a 10-point scale.

Samples packaged in LSAD-300 cellophane were evaluated by an odor panel as well as by a taste panel. After samples were removed from the display case, the backs and wings of each bird were placed in a covered, quart glass jar. The heart, liver, gizzard and neck were placed in a covered pint jar. Four judges recorded the presence of any off-odor.

A series of 4 preliminary experiments were conducted to establish procedures for the objective and subjective tests and to train the judges in distinguishing differences between the flavor of fresh and of stored chickens. The chickens were judged in booths enclosed on 3 sides and equipped with fluorescent lights. Red lights were used during the judging to mask color differences that might bias a judge's evaluation of flavor. Each person judged the same part of the bird at each scoring session. Samples were served hot in heated porcelain dishes. The order in which the 3 coded samples were presented to the judges was randomized.

In designing a study in which the flavor of stored samples are evaluated, the investigator is concerned particularly about a suitable control and the need to prevent a bias that results from a judge's knowledge of the exact age of the sample. In this study, the experiments were planned to overlap to mask the identity of the samples. Two untreated controls were used; one was a whole, eviscerated bird stored continuously in crushed ice. The other control was removed from the ice at the same time as the antibiotic treated sample and was cut-up, packaged and stored in the display case. In the tests in which LSAD-300 cellophane was used, a frozen bird was used instead of the whole fresh bird and served to check on the reliability of the judges' scores.

RESULTS AND DISCUSSION

In reporting the results obtained in this study, it should be pointed out that the storage time as recorded was computed from the time the chickens were received and treated at the laboratory. Since this was one day after slaughter, an additional day must be added to all reported storage times to calculate the time that elapsed between slaughter of the birds and the bacterial or subjective evaluation. Also, one should emphasize that treatment with the antibiotic was not designed primarily to evaluate the effectiveness of the antibiotic in delaying growth of bacteria (this has been reported by other investigators) but rather it was for the purpose of obtaining samples with low bacterial count for flavor evaluation. However, the treatment may give some indication of the effectiveness of the antibiotic even though it was not applied in the chill water at the processing plant.

The results of the bacterial evaluations on whole eviscerated chickens stored in crushed ice (Table 1)

* Trademark of the American Cyanamid Company.

TABLE 1

Total number of viable organisms (per cm²) on the breast and thigh of whole eviscerated chickens stored in crushed ice

Days of Storage	Number of Organisms (x10²) per Treatment					
	Control[1]		Aureomycin[2]		Chlortetracycline[2]	
	B	T	B	T	B	T
0	84	110	94	32	150	55
1	61	78	30	26	32	47
2	86	230	120	48	140	48
3	62	110	93	31	53	84
4	260	960	300	140	210	150
5	...	...	...	...	...	...
6	1,400	4,900	180	220	94	53
7	1,700	11,000	170	270	72	120
8	2,800	15,000	190	130	110	320
9	17,000	72,000	420	340	520	430
10	28,000	40,000	710	4,700	...	...
11	66,000	120,000	...	...	...	...

B = counts obtained on breast by swab method.
T = counts obtained on thigh by swab method.
[1] 6 replicates.
[2] 4 replicates.
[3] 2 replicates.

indicate that the antibiotic was effective in retarding the growth of microorganisms for 10–11 days even though it was applied the day after slaughter. These results are similar to those reported by other investigators who added the antibiotic to the chill water following slaughter *(1, 5, 6)*. Although yeast counts were made, comparatively few organisms were found on any of the samples stored up to 11 days.

The antibiotic applied on the whole chicken inhibited the growth of microorganisms even after the poultry was cut-up, packaged, and stored in the display case for 24–48 hours (Table 2). Although the chickens were processed in a commercial plant, they were cut-up under laboratory conditions which might not duplicate those obtained commercially. In addition, Cryovac packaging appears to delay the growth of bacteria on cut-up broilers more effectively than LSAD-300 cellophane. These data indicate certain trends; however, further study is necessary to determine whether the differences obtained in bacterial counts and flavor scores are statistically significant. It should be pointed out that evaluation by the odor panel indicated the cut-up birds packaged in LSAD-300 cellophane and stored 9 days did not have odors characteristic of incipient spoilage, but the experiment was not continued longer than 9 days because the raw samples did have off-odors then.

Meat flavor scores for the cut-up, packaged broilers stored in the display case summarized in Table 3 indicate that as storage time increased, a gradual deterioration in quality of the chicken occurred regardless of packaging or antibiotic treatment. A comparison of meat flavor scores and skin flavor scores (Figure 1) reveals that with increased storage time, the meat declined more in quality than did the skin. Also, the meat of broilers in a vacuum-type package wrapped in Saran (Cryovac) declined less in quality than that packaged in LSAD-300 cellophane. Throughout the experimental period, antibiotic treated birds stored in the display case 24 to 48 hours did not differ significantly in flavor from the untreated cut-up controls, or from the untreated birds stored whole in ice (Tables 3 and 4).

TABLE 3

Meat flavor scores[1] for control and antibiotic treated cut-up broilers

Storage		Treatment			
Days in:		Cryovac[2]		LSAD-300[2]	
Ice	Display case	Control	Aureomycin	Control	CTC
0	1	9.1	9.3	9.0	9.0
1	..	...	...	...	...
2	1	8.8	9.0	8.6	8.7
3	1	8.9	9.2	8.4	7.7
4	2	8.5	8.5	7.2	7.6
5	..	...	...	...	...
6	1	8.4	8.4	...	...
7	1	8.4	8.1	7.6	7.5
8	1	8.5	8.8	8.1	7.6
9	1	8.5	8.3	...	7.7
10	1	7.7	8.1	...	...

[1] Average for 6 judges.
[2] 4 replicates.
[3] 2 replicates.

Examination of the data (Table 4) to determine the relationship between number of microorganisms and

TABLE 2

Total number of viable organisms (per cm²) on the breast and thigh of cut-up broilers packaged and stored in a commercial display case

Days of storage		Number of organisms (x10²) per treatment							
		Cryovac[1]				LSAD-300[2]			
Ice	Display case	Control		Aureomycin		Control		Chlortetracycline	
		B	T	B	T	B	T	B	T
0	1	56	60	60	115	47	94	38	32
1	1	...	...	...	...	...	...	...	...
2	1	5	70	1	23	120	210	87	37
3	1	2	77	>1	4	180	110	50	120
4	2	340	1,400	11	500	290	1,900	84	44
5	1	...	...	...	...	...	...	...	...
6	1	>1	1,100	1	51	210	360	59	64
7	1	900	4,700	44	98	4,500	21,000	130	210
8	1	650	1,300	22	140	2,100	21,000	110	400
9	1	300	10,000	280	2	...	...	...	...
10	1	12,000	10,000	250	105	...	...	...	...

B = count obtained on breast by swab method.
T = count obtained on thigh by swab method.
[1] 4 replicates.
[2] 2 replicates.

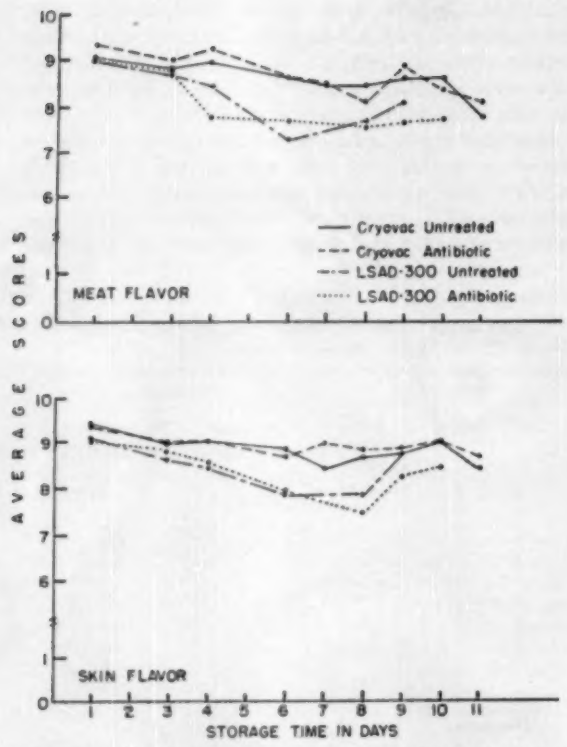

Figure 1. Average scores for meat flavor and for skin flavor of treated and untreated cut-up, packaged, broilers stored in an open refrigerated, display case for 24 or 48 hours.

meat flavor scores for whole chickens stored in crushed ice reveals a tendency for the bacterial counts to increase and the flavor scores to decrease as the storage time increases. However, there are two notable exceptions to this as on the seventh day, the meat flavor scores were low (breast, 7.7 and thigh, 7.9) when the bacterial counts also were relatively low (breast, 17 x 10^4 and thigh, 1.1 x 10^6), and the samples stored 11 days had relatively high flavor scores (breast, 8.3 and thigh, 8.7) even though they had the highest bacterial count (breast, 6.6 x 10^6 and thigh, 12 x 10^6) (Table 4). Apparently factors other than bacterial count are more important in determining the flavor of stored chicken, that is, at least before incipient spoilage becomes evident as determined by appearance and odor. This statement is substantiated by the data for the antibiotic treated birds (Tables 5 and 6) since the flavor of these birds declined with increases in storage time despite the low bacterial counts.

Since the judges' scores indicated that tenderness and juiciness were not affected by the treatments used, no data are reported for these quality characteristics.

In general, the data on numbers of microorganisms reported here are in agreement with those reported by other investigators on the effect of tetracycline antibiotics in delaying the growth of bacteria. However, the subjective evaluation indicated that the flavor changes were not delayed in a similar manner (Tables 5 and 6). A top quality broiler "flavorwise" should score above 8.0. Untreated and treated broilers packaged in LSAD-300 cellophane scored below 8.0 in flavor after a shelf-life of 4–5 days; whereas, untreated and treated samples packaged in a vacuum package (Cryovac) scored below 8.0 after storage for 9 days. Thus, under the conditions used in this study for either treated or untreated cut-up broilers packaged and stored in an open display case top quality broilers "flavorwise" have a shelf-life of 4–5 days or 9–10 days depending on the type of film used. Further it appears that organoleptic evaluation is an important consideration and should be used in any evaluation of the quality of fresh poultry. Since the time this present study was initiated, data reported by Dawson *et al. (5)* would substantiate this conclusion. Also, from results obtained in an odor evaluation of antibiotic treated poultry, Vaughn *et al. (8)* concluded that, "In general, total psychrophilic bacterial counts proved to be an unreliable index of organoleptic quality."

In a recent report on a study of the quality of ice-packed and dry-packed poultry, Baker *(2)* gave taste panel scores for flesh flavor that indicated that untreated broilers were superior to chlortetracycline treated poultry.

TABLE 4

Relationship betweeen bacterial counts (x10^2) and meat flavor scores for whole chickens stored in crushed ice

Storage in days	Breast Org./cm²	Breast Score	Thigh Org./cm²	Thigh Score
1	60	10.0	78	9.0
3	62	8.7	110	9.0
4	270	8.8	950	9.3
6	1,400	8.6	4,900	9.1
7	1,700	7.7	11,000	7.9
8	2,900	8.6	15,000	8.0
9	17,000	8.5	72,000	8.5
10	28,000	8.4	40,000	7.8
11	66,000	8.3	120,000	8.7

TABLE 5

Relationship between bacterial counts (x10^2) and meat flavor scores[1] for control and aureomycin treated cut-up broilers packaged in Cryovac

TREATMENT	STORAGE Days in: Ice	STORAGE Days in: Display case	Breast Org./cm²	Breast Score	Thigh Org./cm²	Thigh Score
Control	0	1	56	9.1	60	9.2
Aureo.	0	1	60	8.9	120	9.6
Control	2	1	5	8.5	70	9.1
Aureo.	2	1	1	8.8	23	9.1
Control	4	2	340	8.1	1,400	8.8
Aureo.	4	2	11	8.5	500	8.6
Control	8	1	650	8.3	1,300	8.8
Aureo.	8	1	22	8.9	140	8.7
Control	10	1	12,000	7.6	10,000	7.8
Aureo.	10	1	250	7.8	105	8.4

[1] Average of 24 scores (6 judges × 4 replicates).

TABLE 6

Relationship between bacterial counts (x10^2) and skin flavor scores[1] for control and aureomycin treated cut-up broilers packaged in Cryovac

TREATMENT	STORAGE Days in: Ice	STORAGE Days in: Display case	Breast Org./cm²	Breast Score	Thigh Org./cm²	Thigh Score
Control	0	1	56	9.1	60	9.2
Aureo.	0	1	60	8.9	120	9.6
Control	2	1	5	8.5	70	9.1
Aureo.	2	1	1	8.8	23	9.1
Control	4	2	340	8.1	1,400	8.8
Aureo.	4	2	11	8.5	500	8.6
Control	8	1	650	8.3	1,300	8.8
Aureo.	8	1	22	8.9	140	8.7
Control	10	1	12,000	7.6	10,000	7.8
Aureo.	10	1	250	7.8	105	8.4

[1] Average of 24 scores (6 judges × 4 replicates).

TABLE 6

Relationship between bacterial counts (x10^2) and meat flavor scores[1] for the control and the CTC treated cut-up broilers packaged in LSAD-300 cellophane

TREATMENT	STORAGE Days in:		Breast		Thigh	
	Ice	Display case	Org./cm^2	Score	Org./cm^2	Score
Control	0	1	47	9.2	94	8.8
CTC	0	1	38	8.7	32	9.2
Control	2	1	120	9.0	210	8.2
CTC	2	1	87	8.8	37	8.5
Control	4	2	290	7.5	1,900	7.0
CTC	4	2	84	7.5	44	7.7
Control	8	1	2,100	8.3	2,000	7.8
CTC	8	1	105	7.8	400	7.2

[1] Average of 12 scores (6 judges × 2 replicates).

SUMMARY

Bacterial and organoleptic evaluations on cut-up, packaged broilers were made at regular intervals up to 11 days of storage. After treamtent with (1) no antibiotic, (2) Aureomycin as prepared for the Acronize process and (3) crystalline chlortetracycline, birds were stored in crushed ice and then cut-up, packaged and stored for 24 to 48 hours in an open display case. Two types of packaging films, Cryovac and LSAD-300 cellophane, were used. Bacterial counts were made before packaging and just before cooking. Sensory evaluations were made by a taste panel on the deep-fat fried samples.

Meat flavor scores indicated that as storage time increased a gradual deterioration in quality of the chicken occurred regardless of packaging or antibiotic treatment. The antibiotic treatment retarded the growth of bacteria whether the bird was stored whole in crushed ice or cut-up, packaged, and stored 24 or 48 hours in a display case. Broilers, vacuum packed and wrapped in Cryovac, frequently had lower bacterial counts and higher flavor scores than those packaged in LSAD-300 cellophane.

During storage of the untreated birds, the number of microorganisms increased and the flavor decreased. Further, insofar as the antibiotic treatment was concerned, the preservative effect was limited to inhibiting the growth of the bacteria since the flavor of the untreated and treated samples did not differ significantly. It is suggested that other undetermined factors are equally or more important than bacterial counts in determining the flavor of stored poultry.

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A Survey of the Bacteriological Quality of Frozen Poultry Pies*

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VARIOUS PROBLEMS of a microbiological nature are encountered in the production and distribution of precooked frozen foods. Often, such problems stem from technological and sanitary inadequacies in the preparation of the products. In manufacturing precooked frozen poultry pies, for example, after cooking the bird carcasses, it is customary to pick the meat from the bones by hand *(10)*. This operation causes the meat to be recontaminated. The extent of the contamination, however, may be controlled by the practice of good operating procedures. After boning and chilling the meat is diced and stored, sometimes without adequate rechilling and refrigeration until used in the pie filling *(10)*. Weighing of the diced meat and transferring it to the pie may be performed by hand. A time interval, of variable length, elapses between packaging and freezing.

All these processing steps result in an increase of the bacterial population of the product, and the size of this increase is related to the sanitary and technological procedures employed.

Other bacteriological problems may arise during the distribution of the product, as the frozen food is moved through warehouses, order-assembly rooms, and delivery trucks to the retail store *(10)*. Microbial growth may ensue if the frozen products are inadequately refrigerated during any of these steps. Gunderson *(4)* has demonstrated that during improper handling and distribution, the psychrophilic population may increase to the point where the product may be considered spoiled.

How the consumer will handle the precooked frozen food is unpredictable. The product may be exposed to room temperatures and allowed to defrost; it may be baked for a shorter period of time than indicated on the package and it may be held without refrigeration after baking. Evidence is presented in this paper that baking the frozen pie according to the given directions does not always destroy the potential food poisoning microorganisms which may be present in the product.

Presence of bacteria of the food poisoning type has been demonstrated in commercially-prepared frozen foods. Coagulase-positive strains of *Staphylococcus aureus* were isolated by Gunderson *et al. (5)* from precooked frozen foods. Saleh and Ordal *(9)* detected botulinum toxin in grossly mishandled precooked frozen chicken a la king. *Salmonella* spp. and coagulase-positive staphylococci were isolated in the course of the present investigation from commercially-prepared precooked frozen poultry pies.

The present investigation was undertaken to determine the bacteriological quality of some commercially-prepared precooked frozen foods obtained on the retail market. In a preliminary survey, it was found that poultry pies had a higher degree of bacterial contamination than did other types of precooked frozen foods. Because of this information and because poultry pies are a very popular precooked frozen item, it was decided to confine the investigation to frozen chicken and turkey pies.

EXPERIMENTAL METHODS

The frozen pies were purchased at several retail stores in the Champaign-Urbana area. Five different brands, designated A, B, C, D, and E, were chosen.

Manufacturer's code numbers on the packages were noted and care was taken to select pies which had different code numbers. This procedure made possible a more representative sampling of the products. Pies were purchased over a period of approximately 8 months.

Bacterial counts were determined for (a) frozen unbaked pies as purchased on the retail market, (b) pies after baking them in an oven whose temperature was constantly kept at the desired level by the use of a recording potentiometer, and (c) pies after baking them under conditions simulating those that may be encountered in the ordinary family kitchen.

(a) Frozen unbaked pies. A 25 g. portion of the frozen pie was weighed into a sterile Waring blender; this portion was cut out from the center of the pie with a knife that had been dipped in alcohol and flamed. Then 225 ml. of sterile distilled water was added and the whole was blended for 3 minutes. This 1:10 dilution was used to prepare the other dilutions needed.

Total counts were determined by plating aliquots of the suspension with tryptone glucose extract agar (Difco). Violet red bile agar (Difco) was used for the enumeration of coliforms. Enterococcus counts were determined with the medium developed by Reinbold *et al. (8)*. Surface plating on tellurite-glycine agar *(11)* was used for the quantitative determination of coagulase-positive staphylococci. Violet red bile agar plates and the tellurite-glycine agar plates were incubated at 37° C. for 24 hours, whereas plates for the total count and the enterococcus count were incubated for 48 hours at 37° C.

The Most Probable Number (MPN) per gram of sample, of *Salmonella* and of those paracolons that were similar to *Salmonella* because of their physiological behavior, was determined. Procedure followed was similar to the one used by Byrne *et al. (2)* for determining the number of *Salmonella* in dried eggs. Selenite-F broth (BBL) was used for the enrichment cultures, which were prepared in serial dilutions. After incubation at 37° C. for 24 hours a loopful from each of the enrichment tubes was streaked on a plate of brilliant green agar (Difco) and on a plate of SS agar (Difco). After incubation at 37° C. for 24 hours, one well-isolated, non-lactose

* Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 14, 1956.

fermenting colony was picked from each plate which contained colonies suspected of being *Salmonella*, and transferred to triple sugar iron agar (Difco). If both the brilliant green and SS agar plates, which had been streaked with a loopful from the same enrichment culture, had colonies typical of *Salmonella*, then only one colony, from either plate, was picked. Those cultures showing a characteristic *Salmonella* reaction on triple sugar iron agar slants were tested for urease production, indole production, motility and Gram reaction. Urease-negative, indole-negative, motile and Gram-negative cultures were considered to be either *Salmonella* or paracolons physiologically similar to *Salmonella*. From the number of positive selenit-F enrichment tubes the MPN of Salmonella-Paracolon organisms per gram was then calculated *(1)*. Slide agglutination tests with *Salmonella* polyvalent serum (Lederle) were performed on a number of cultures isolated as indicated above.

(b) Pies baked in an oven regulated by a potentiometer. In baking these pies, the directions printed on the packages (see Tables 3 and 4) were followed. Oven preheating time was never indicated in the directions. The pies were always to be baked in the frozen state.

A gas oven was used for baking the pies. Temperature of the oven was constantly determined by using 2 copper-constantan glass insulated thermocouples whose terminals were connected to a Brown Honeywell recording potentiometer. The hot junctions of the 2 thermocouples were placed inside the oven so that readings of the temperature at the left and right side of the oven were recorded by the potentiometer. By means of this set-up it was possible to keep the oven constantly at the temperature specified by the instructions for baking the pies. The gas flame in the oven was adjusted by using the oven regulator.

The directions on the packages of the pies of brands A, B, C and D suggested baking times ranging from 30 to 40 minutes at 425° F., or until the pie crust was golden brown (Tables 3 and 4). It was found, however, that after 25–30 minutes of baking, the crusts had an uneven brownish color, more accentuated toward the periphery, which gave the pies a cooked appearance. In view of this observation, the pies were always baked according to the times and temperatures suggested by the manufacturers, which were sufficient to cause browning of the crust.

Pies of brand E were baked for 25 minutes at 450° F. and then at 500° F. until golden brown (2 to 5 minutes).

With each pie baked for the purpose of making quantitative determinations of its bacterial content, another identical pie was baked at the same time in the same oven only for the purpose of determining the pie temperature during baking. This second pie had the hot junction of a glass-insulated thermocouple inserted away from the center and near the edge of the pie. It was assumed that the heat would penetrate the two identical pies at the same rate during baking. Therefore, the temperatures recorded for the pie containing the thermocouples were considered to be representative for the other pie. The terminals of the thermocouples inserted in the pies were connected with the same Brown Honeywell potentiometer that registered the temperatures of the oven. After the pies were removed from the oven, they were kept at room temperature for 5 minutes before a sample was taken for bacteriological evaluation. The determinations and the methods were the same as those used on the unbaked pies.

(c) Pies baked under conditions similar to those that may be encountered in the ordinary family kitchen. These pies were baked in the gas oven of a Hardwick kitchen range, about one year old, which required approximately 10 minutes to reach a baking temperature of 425° F., and about 10.8 minutes to reach a baking temperature of 450° F. The oven regulator, whose accuracy was found to be good by potentiometric measurements, was used to set the oven at the desired temperature. A potentiometer was not used to record and adjust the temperature of the oven while the pies were being baked.

The oven was preheated for 5 minutes, with the oven regulator set at the desired temperature, before the frozen pies were placed in it. This preheating time was arbitrarily selected as being representative of what might be commonly encountered in an ordinary family kitchen.

With each pie baked for the purpose of bacteriological testing, a second identical pie was baked to determine the temperature at its center after baking.

Bacterial counts were determined by the same procedures used for the unbaked pies. To provide a more direct means of comparison between the bacterial counts of the pies before and after baking, an identical pie, of the same brand and manufacturer's code number, was purchased together with each pie to be baked and tested bacteriologically. This pie was not baked but was evaluated by the previously described bacteriological procedures. If both pies, which had the same manufacturer's code number, originated from the same batch, then their degree of contamination should have been approximately the same.

RESULTS AND DISCUSSION

A. Frozen unbaked pies. The microbiological data obtained in the evaluation of the frozen unbaked pies are presented in Table 1.

It is immediately apparent, from an inspection of these data, that the 5 brands differ with regard to their microbiological quality.

If total counts and coliform counts are chosen as a basis of comparison, samples of Brands A and E, with some exceptions in each series, had counts consistently lower than those of the other 3 brands. Brand B samples were at the other extreme; high total and coliform counts were generally obtained from pies of this brand. Samples of brands C and D were of intermediate bacteriological quality. If the coagulase-positive staphylococcus counts are also considered, a difference in the type of contamination between brands A and E becomes evident. The higher staphylococcal counts of the samples of Brand E would imply that the manufacturer of these pies could make further operating improvements, which would reduce the numbers of these organisms in the product.

Enterococci were demonstrated in all the samples tested and they were nearly always more numerous than the coliforms. Also enterococci were always found when coliforms were absent. Although this repeated detection of enterococci may point to them as good indicators of fecal contamination in frozen foods, it may also raise questions as to the significance of their constant presence in such products. Johnson and Mundt *(6)* recently reported the isolation of enterococci from a variety of raw plant materials and from the atmosphere of vegetable freezing plants. Their results emphasize the need for additional information on the habitat of these organisms and likewise question the practicality of using this group of organisms as indicators of fecal contamination in food products containing vegetable material. The significance of the enterococcus counts reported here (Tables 1, 3 and 4) in relation to a potential food poisoning hazard is also limited by the fact that identification of species was not carried out. Alpha-type strains of *Streptococcus fecalis* are the only members of the group reported to be involved in food poisoning outbreaks *(3)*.

More significant are the results obtained in testing for coagulase-positive staphylococci. Only 3 samples

TABLE 1

Bacterial counts of frozen uncooked pies

Microorganisms per gram

Brand[1]	Total count	Coliforms	Enterococci	Coagulase-Positive Staphylococci	Salmonella-Paracolon MPN
A	20,000	0	90	750	0
	3,700	0	.....	0	0
	16,000	20	60	450	0
	15,000	0	75	700	0
	16,000	5	90	350	0
	290,000	130	1,200	39,000	2
	60,000	10	90	750	1
	16,000	5	70	1,500	1
B	2,200,000	1,200	160,000	3,100	10
	16,000	140	.....	160	17
	3,900,000	850	6,600	39,000	100
	1,100,000	70	25,000	390,000	21
	3,300,000	2,100	2,200	0	1,200 plus
	110,000	90	890	13,000	1
	1,100,000	130	4,000	1,200	48
	200,000	200	5,400	1,000	2
C	280,000	10	320	14,000	1
	300,000	350	25,000	12,000	1
	630,000	0	4,200	10,000	0
	240,000	5	980	13,000	1
	120,000	0	.....	2,800	1
	69,000	0	610	25,000	0
	62,000	20	1,900	300	1
	87,000	0	4,800	2,800	0
D	110,000	10	810	7,300	1
	220,000	20	13,000	25,000	1
	66,000	0	540	4,200	0
	750,000	0	100	5,000	1
	1,400,000	1,200	930	14,000	2
	720,000	40	15,000	41,000	1
	1,100,000	35	1,600	4,000	4
	75,000	5	100	4,200	0
E	180,000	100	18,000	43,000	1
	65,000	0	2,400	3,600	1
	27,000	0	1,000	2,500	1
	48,000	5	1,100	5,400	1
	64,000	0	620	0	0
	24,000	5	750	6,600	1
	84,000	0	2,400	150	0
	34,000	60	440	3,500	1

[1] For each brand, the data for the first four samples are for frozen chicken pies, whereas the last four are for frozen turkey pies.

out of 40 were negative for these organisms. In 28 of the 40 pies whose bacterial counts are reported in Table 1, the coagulase-positive staphylococcus counts were above 1,000 per gram. The selectivity of the tellurite-glycine agar used for these counts was checked by testing colonies that had developed on it after inoculation with dilutions of the pies, by means of the coagulase test. Of 30 such colonies tested only 2 proved to be coagulase-negative.

Staphylococci are capable of growing in precooked frozen foods at room temperature *(7)*. Gross mishandling of the products would result in growth of the staphylococci and in possible enterotoxin formation. In one of the samples of brand B, 390,000 coagulase-positive staphylococci per gram were detected. In such a case, should the pie be held at room temperature due to mishandling, the staphylococci would require only a short time to multiply to a level at which they could produce a significant amount of enterotoxin.

The occurrence of coagulase-positive staphylococci in nearly all the samples evaluated, emphasizes the fact that constant vigilance must be maintained over the technological and sanitary procedures used in the manufacture of precooked frozen foods of this type. Although it may be difficult to produce poultry pies which are constantly free of these organisms, certainly the operation should be such that their number will be low in the final product.

With the exception of most samples of brand B, the Salmonella-Paracolon MPN's of the pies was low, and in fact their numbers bordered on the sensitivity of the method used. Of the 20 samples which had a total count of over 100,000 per gram, 19 contained these organisms, whereas of the 20 samples which had a total count below 100,000 per gram, only 9 samples were positive.

Slide agglutination tests with *Salmonella* polyvalent serum were performed on 51 cultures that gave a typical *Salmonella* reaction when tested physiologically as previously described. Only 5 of these cultures, or about 10%, were agglutinated by the serum, and were classified as *Salmonella* spp. Three of these 5 cultures came from samples of brand D and the other two from samples of brand B. It is interesting to note that these two brands were the two having the highest total counts. There likewise appeared to be some correlation between the number of coliforms and the presence of Salmonella-Paracolons in the pies (Table 2).

B. Baked pies. Table 3 presents the data obtained when the pies were baked in an oven in which the

TABLE 2

Correlation between the number of coliforms and the presence of Salmonella-Paracolons in frozen poultry pies

Coliform count	Number of pies	Number of pies containing Salmoonella-Paracolons	Per cent of pies with Salmoonella-Paracolons
Above 10/g.	18	17	94
10/g. or less	22	11	50
None	13	4	31

temperature was controlled by a recording potentiometer. Figure 1 illustrates the temperatures at the center and away from the center of one of the above pies, baked at 425° F. for 40 minutes, according to the directions specified on the package. It will be noted from the data in Table 3 that the destruction of the non-spore forming organisms, while not complete, was satisfactory, especially at the longer baking times. The data indicate that the baking time is more important in the destruction of the microbial flora than is the oven temperature (Tables 3 and 4).

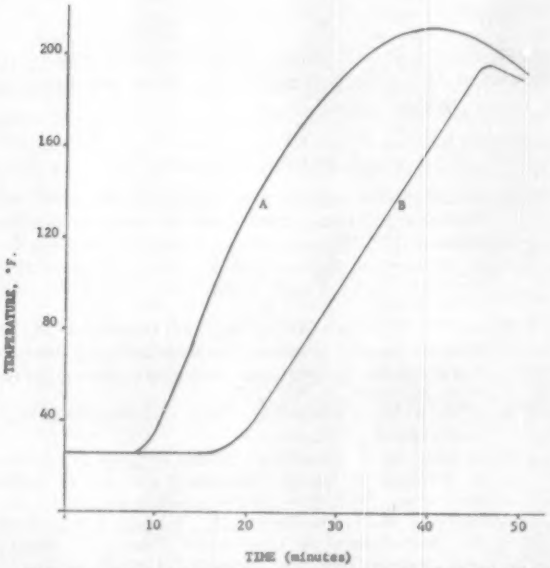

Figure 1. Temperature changes in poultry pie during baking. The pie was removed from the oven after 40 minutes at 425° F. Curve A = temperatures away from the center of the pie. Curve B = temperatures at center of pie.

These observations are further emphasized by the data obtained with pies baked under conditions similar to those that may be encountered in an ordinary family kitchen (Table 4). Inspection of the data in this table indicates that pies of brands A and D which were baked for 40 minutes with the oven regulator set at 425° F., had maximum center internal temperatures ranging from 165° to 189° F. and that such temperatures were sufficient to destroy the non-pore forming organisms tested for. The baking times and temperatures specified for the other brands were not sufficient to produce a high enough center temperature to cause much, if any, destruction of the undesirable organisms present in the pies. In fact, the directions for brand E were such that the center temperatures only came up to a good incubation temperature. It should also be noted that, in general, the center temperature did not stay at a point sufficiently high for a period of time long enough to inactivate staphylococcal enterotoxin, should it be present in the pie. Dack *(3)*, who has reviewed the literature on the heat resistance of staphylococcal enterotoxin, reports that its potency is gradually reduced following prolonged boiling or autoclaving.

The data which have been presented demonstrate that there is considerable variation in the microbiological quality of frozen poultry pies, as they are currently being sold on the retail market. The microbiological quality of some brands is consistently good whereas the quality of others is to be questioned. As these products contain microorganisms which have a food poisoning potential, manufacturers should exert every effort toward reducing the actual numbers present by the inauguration of improved technological and sanitary measures, and by use of strict quality control procedures. Likewise, further consideration should be given to the baking times supplied on

TABLE 3

Bacterial counts of pies baked at temperatures controlled by a recording potentiometer

	Microorganisms per gram				
	Total Count	Coliforms	Enterococci	Coagulase-Positive Staphylococci	Salmonella-Paracolon MPN
Brand A: Bake at 425° F. for 40 minutes or until crust is golden brown	3,000	0	0	0	0
	500	0	0	0	1
Brand B: Bake at 425° F. for 30-35 minutes or until crust is golden brown	10,000	0	560	700	1
	40	0	0	0	0
Brand C: Bake at 425° F. for 30 minutes or until crust is golden brown	4,200	0	0	0	0
	11,000	0	330	1,300	0
Brand D: Bake at 425° F. for 38-40 minutes or until crust is golden brown	1,700	0	0	0	0
	490	0	0	0	0
Brand E: Bake at 450° F. for 25 minutes, turn oven to 500° F. and bake until golden brown	12,000	5	280	400	1
	30,000	0	880	1,500	0

TABLE 4

Bacterial counts of pies baked under conditions simulating those ordinarily encountered in a household kitchen

	Microorganisms per gram					
	Total count	Coliforms	Enterococci	Coagulase-Positive Staphylococci	Salmonella-Paracolon MPN	T[1]
Brand A: Bake at 425° F. for 40 minutes or until crust is golden brown	20,000/1,200	0/0	90/0	750/0	0/0	189
	16,000/1,000	5/0	70/0	1,500/0	1/0	165
Brand B: Bake at 425° F. for 30-35 minutes or until crust is golden brown	2,200,000/1,800,000	1,200/70	160,000/80,000	3,100/3,000	10/1	121
	20,000/25,000	200/300	5,400/2,700	1,000/1,100	2/1	126
Brand C: Bake at 425° F. for 30 minutes or until crust is golden brown	280,000/190,000	10/0	320/790	14,000/2,500	1/1	128
	87,000/44,000	0/0	4,800/1,500	2,800/6,400	0/0	124
Brand D: Bake at 425° F. for 38-40 minutes or until crust is golden brown	110,000/910	10/0	810/0	7,300/0	1/0	173
	75,000/2,100	5/0	110/0	4,200/0	0/0	181
Brand E: Bake at 450° F. for 25 minutes, turn oven to 500° F., bake until crust is golden brown	180,000/530,000	100/220	18,000/15,000	43,000/110,000	1/1	106
	34,000/27,000	60/0	440/1,200	3,500/5,100	1/1	108

[1] T = Temperature (F.) at center of baked pie 4 minutes after removing from oven.
Numerator: unbaked pie used as control.
Denominator: baked pie.

each package, and perhaps efforts should be directed toward the formulation of crusts which will brown more slowly at the baking temperature. This would encourage longer baking times with a subsequent improved rate of thermal destruction of the microbial flora present. It is our opinion that the greatest public health hazard would come from pies that were baked and not consumed immediately, and which were improperly refrigerated between baking and consumption.

SUMMARY

Precooked frozen chicken and turkey pies as produced by five different manufacturers were examined quantitatively for bacterial contamination.

The examination of unbaked frozen pies indicated differences in amount of bacterial contamination among the five brands, probably reflecting the nature of the sanitary and technological methods followed by the five manufacturers. Of the 40 unbaked pies that were tested, 20 had total counts above 100,000 per gram, and 18 had coliform counts above 10 per gram. Enterococci were present in all the samples tested and coagulase-positive staphylococci were detected in 37 of 40 pies tested. Five *Salmonella* cultures were isolated from the unbaked pies.

The microbiological data obtained when the pies were baked indicated that the baking time and temperatures specified for some of the brands under consideration were not sufficient to cause destruction of the non-spore forming organisms tested for. In view of the fact that the frozen pies contain microorganisms which have a food poisoning potential, it is suggested that (a) efforts should be directed towards the introduction of improved technological and sanitary measures in the preparation of these products, (b) further consideration should be given to the baking times suggested on each package, and (c) pie crusts should be formulated which would brown more slowly at the baking temperature, thus encouraging a longer baking time.

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Application of Work Measurement to the Determination of Fibrousness in Asparagus[a, b]

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PREVIOUS WORK at the University of Maryland has indicated that the shear-press is applicable to the measurement of fibrousness of asparagus *(5)*. As a result of the recent adaptation of shear resistance instruments for electrical indicating and recording, it is now possible to obtain not only the force required to overcome the resistance offered by the food sample at the maximum point, but a complete time-force curve for the entire stroke *(1)*.

This work was therefore undertaken in order to determine what additional information could be obtained from these time-force curves that could not be obtained from maximum force indications alone. Specifically, the following points were investigated in regard to their effects on results obtained in terms of time-force curves as compared to maximum force indications:

1. Sample size.
2. Speed of stroke.
3. Size of asparagus stalks.
4. Sample stratification.
5. Variability in fibrousness within the sample.
6. Extent of correlation with fibrousness.

MATERIALS AND METHODS

Asparagus stalks were harvested daily during the period from April 30 to May 7, 1956, from plots grown on the University of Maryland Plant Research Farm. With the exception of one lot which was held for storage studies, each day's harvest was brought to the Beltsville Plant Industry Station where shear-press determinations were obtained within 4 to 8 hours after harvest. After cutting by the blade of the asparagus test cell of the shear-press, the respective portions of each sample were then packed separately in frozen food containers with no further treatment, frozen at −20° F., and stored at 0° F. at the University of Maryland until they were analyzed for fiber content by the Blendor method *(2)*.

The area under each time-force curve was integrated by the use of a planimeter. Since the correlations between percentage fiber and shear-press values exhibited some curvilinearity, rank correlations were calculated for all preliminary results, while for the more definitive results, curves of best fit were obtained by the least squares method *(4)*.

RESULTS AND DISCUSSION

1. Sample size. Since the asparagus test cell consists of one blade which cuts through the sample at one surface *(5)*, sample size is measured in terms of area, rather than volume or weight. Thus, in order to determine the additiveness and linearity of the relation of sample area to shear-press values, several series of samples were prepared consisting of groups of stalks varying in combined area from approximately one to 6.9 square inches, which is the area of the completely filled sample box of the asparagus test cell. For each sample, the total work value as determined by the integration of the area under the time-force curve, was divided by the respective sample area. Thus, all results were reported on a one square inch sample basis. The linear correlation of these values with percentage fiber was 0.87, the rank correlation 0.91, and the correlation of the logarithms of the work values with percentage fiber was 0.93. These results, shown in Figure 1, demonstrate the high correlation between work values and fiber content of asparagus, and the logarithmic nature of this relationship.

Eight series of samples comprising a total of 40 analyses began with completely filled boxes, followed by half filled boxes, etc., as shown in Table 1. It was found that as the sample size is cut in half, the work value is correspondingly cut approximately half; however, the maximum force required to shear is reduced by considerably less than half.

2. Speed of stroke. It has been established previously that the rate of application of force has an effect on maximum force as indicated by a dial gauge *(3)*. In order to secure information on the effect of this factor on registration of work, the shear-press

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[c] Employed jointly by the Biological Sciences Branch, Agricultural Marketing Service, USDA, and University of Maryland.

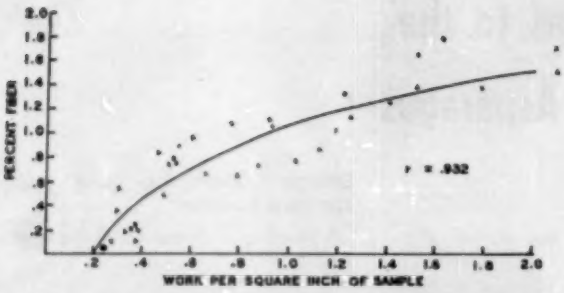

Figure 1. Relation of percent fiber to work per square inch of sample, as influenced by sample size. • indicates samples having a total cutting area of one square inch, x = 2 square inches, △ = 4 square inches, and ◇ = full box.

was set for 6 different speeds, so that the curve was recorded on chart lengths varying from 2.1 to 32.0 inches. The results on 12 samples are presented in Table 2, and show the relation of work and maximum force, to percentage fiber, as affected by the speed of the stroke. These results demonstrate that the speed of stroke greatly influences the area under the curve, and also has a definite effect on the maximum force. Thus, the rank correlation between percentage fiber and the curve area for this series of samples was only 0.37, which for so small a number of comparisons was not even statistically significant. However, when the curve areas were divided by the respective lengths of the chart so that they were all on an equivalent speed basis (Table 2, column 3), the rank correlation between these adjusted work values and per cent fiber rose to the very satisfactory level of 0.96. The correlation between fiber content and maximum force was originally 0.86 and was improved to 0.93 by an arbitrary adjustment of the maximum force values, this adjustment being based on the relationship of maximum force to percentage fiber, when the speed of stroke is held constant.

3. Size of stalks. It has been established previously that when individual asparagus stalks of equal fiber content are tested the shearing force increases with increasing stalk diameter *(2)*. This is primarily a sample area effect. It would be of interest to know what effect the stalk diameter has on maximum force and on work when fiber content and total sample area are held constant.

TABLE 1

Relation of sample size to work and maximum force required to shear asparagus stalks
(Each value represents an average of 8 samples)

Sample size		Work value		Maximum point	
Square inches	Percent of full box	Area under curve in square inch	Percent of full box	Percent of scale	Percent of full box
6.9	100	5.3	100	52	100
3.5	51	3.0	55	42	81
1.7	25	1.4	26	33	63
.85	12	.80	15	24	46
.42	6	.35	7	14	27

TABLE 2

Effect of speed of stroke on the relation of work and maximum force required to shear asparagus stalks, to percent fiber

Speed, as inches of chart travel	Work value		Maximum force		Percent fiber
	Area under curve square inch	Per inch of chart	Percent of scale		
			Actually observed	After arbitrary adjustment	
32.0	55.7	1.74	80	62	1.18
32.0	13.4	.42	21	16	.12
12.5	19.3	1.54	76	63	.94
12.5	5.2	.42	22	18	.16
6.6	8.2	1.24	62	56	.68
6.6	2.7	.42	22	20	.18
4.2	5.4	1.32	58	58	1.08
4.2	1.9	.45	20	20	.38
2.8	5.8	2.11	81	90	1.42
2.8	1.4	.51	24	27	.48
2.1	3.7	1.76	66	83	1.63
2.1	1.5	.71	23	29	.30

To determine this point, 3 series of samples comprising a total of 27 determinations were tested in which stalk size was varied and both total sample area and fiber content maintained nearly constant. Although it was not established with statistical certainty, there was an indication that work values were not influenced by stalk size, but that maximum force values tended to increase slightly with decreasing size of stalk for the same fiber content.

4. Sample stratification. Lots of asparagus are extremely variable in fibrousness. It was therefore considered important to determine the effect of the method of loading the sample on shear-press results. Thus, in another series of tests, samples were first sorted visually for differences in apparent fibrousness, and the most fibrous units placed on the bottom, middle, or top of the sample box. For these data also, an analysis of variance did not establish the existence of difference with statistical certainty. There were indications, however, that such sample stratification had no effect on the relation of work values to fiber content, but the maximum force values tended to be somewhat higher for the same fiber content, if all the tough units are placed on the top of the sample.

5. Variability in fibrousness within the sample. Shear-press values, whether in terms of work as shown by the area under the time-force curve, or in terms of maximum force, may be used to indicate average fibrousness of a lot of asparagus. Such information may be used as a guide for determining whether a lot of asparagus *on the average* will be of sufficient tenderness. The asparagus processor, however, is interested not only in the average fibrousness, but also in the distribution of fibrousness within the lot. Thus for example, if stalk segments at a certain distance from the tip average 1.0% fiber rather uniformly, all of these segments may be discarded; however, if the lot is extremely variable, there may still be a substantial portion of tender material that may be utilized, and only the more fibrous units discarded.

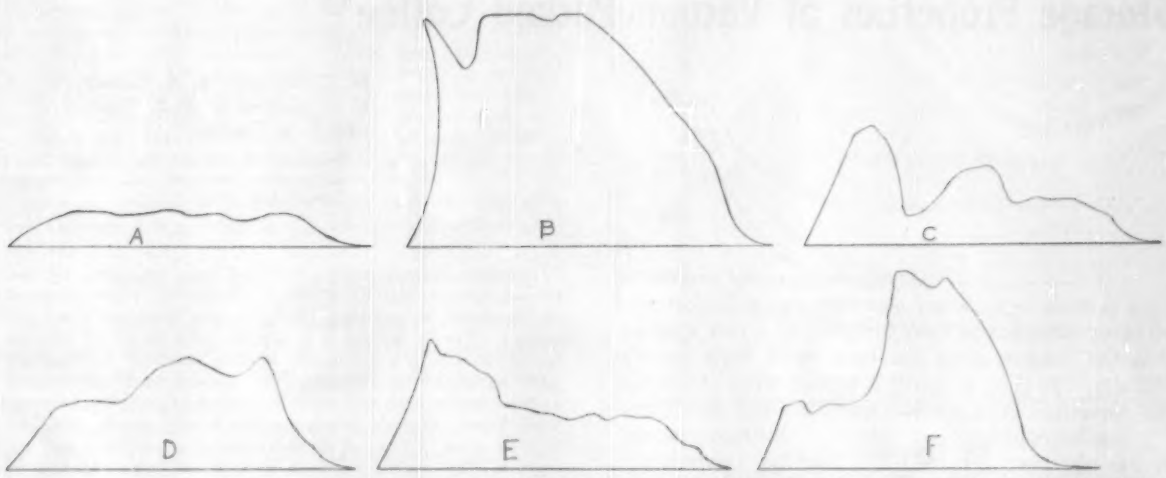

Figure 2. Some characteristic time-force curves obtained with the recording shear-press on asparagus. A = uniformly tender asparagus, B = uniformly tough asparagus, C = one tough stalk at bottom of sample, D = one tough stalk at the top of the sample, E = several increasingly tough stalks at the bottom of the sample, F = several tough stalks at the top of the sample.

An examination of the time-force curve provides the opportunity of estimating the variability within the sample. In Figure 2, examples are shown of a number of types of curves illustrating how such variability may be interpreted. A sharp peak indicates the presence of a single fibrous stalk, whereas a plateau indicates the presence of several stalks of equal fibrousness. A sustained plateau showing only small peaks and dips indicates uniform material, with the height indicating the degree of fibrousness.

It may be feasible to establish some variability ratio from data provided by time-force curves. This will be investigated during the 1957 season, along with procedures for including such measurements in quality control and grading procedures.

6. Correlation with fiber content. In order to determine whether work values provide any better information on the fibrousness of asparagus than dial indications of maximum force, rank correlations were calculated for 6 separate sets involving 114 individual samples. Correlations between work and maximum force ranged from 0.81 to 0.98, indicating that in general, these two types of data provided the same kind of information. Correlations between work values and percentage fiber ranged from 0.79 to 0.96, while those between maximum force and percentage fiber were from 0.67 to 0.93. These somewhat higher correlations with work values may be due to a number of factors, such as those discussed above.

SUMMARY

Time-force curves obtained with an electrical indicating and recording shear-press provided additional and more precise information on fibrousness of asparagus than maximum force indications alone. Average fibrousness may be indicated in terms of work per square inch of sample, at a given speed of stroke. Stalk diameter and sample stratification have some effect on maximum force values, but the effects on work values may not be as great. Variability within the lot may be observed by examination of the work curves. Additional research is needed to establish a variability ratio based on these curves.

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Storage Properties of Vacuum-Packed Coffee[a, b]

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(Manuscript received May 14, 1957)

In recent years coffee producers have become increasingly conscious of the importance of flavor retention in their product. It is now realized that the product must not only be of high quality initially, but must retain this quality when it reaches the consumer. As a means toward this end, the industry has recognized great value of vacuum-packing. It has also been generally felt that low temperature storage of coffee would aid in flavor retention.

Beneficial effects on quality retention from storage of coffee at 32–35° F. (0–1.7° C.) were reported by Baker *(2)*. Wyler *(9)* advocated storage of coffee at 37.4–41.0° F. (3–5° C.) or even at subzero temperatures for preservation of coffee flavor. Mabrouk and Deatherage *(5)* found −4° F. (−20° C.) satisfactory as a storage temperature. Little detailed information exists in the literature, however, on what happens to the flavor of vacuum-packed coffee at varying temperatures of storage. The present investigation was therefore undertaken to gain a clearer understanding of the physical and chemical changes that take place in stored, vacuum-packed coffee and their effect on flavor retention as influenced by temperature.

EXPERIMENTAL

Material. The coffee for this study was a blend selected from several as an acceptable brand. It was a Silex-grind type, vacuum-packed in one-pound cans, and stored at temperatures of −20° F. (−29° C.), 36–40° F. (2–4° C.), 68° F. (20° C.), and 99° F. (37° C.). At specified intervals, namely, 1, 2, 3, 6, 12, and 27 months, samples were removed from their respective storage rooms and equilibrated for 24 hours at 68° F. The vacuum in the cans was measured and the punctures were sealed immediately with electrical tape. The cans were then held at a temperature of 36–40° F. for analysis of volatiles remaining in the ground coffee and for organoleptic tests.

Vacuum measurements. The vacuum in the cans was measured with an F.I.R.A. Patent Canned Products Vacuum Gauge (Budenberg Gauge Company, Ltd., Broadheath, England), graduated in 0–30 inches of mercury. Two readings were taken on each can in accordance with the manufacturer's instructions, making it possible to calculate a final vacuum value, corrected for air present in the gauge.

Vacuum measurements were made on 6 cans from each storage temperature except for the 27-month interval when only 3 to 5 cans were available for testing.

Chemical measurements. Carbonyl was estimated by the chromatographic method of Pool and Klose *(7)* which measures monocarbonyl compounds. Carbonyl was extracted from the ground coffee by shaking 5 g. samples with 50 ml. of benzene for 10 minutes in a mechanical shaking machine. All analyses were performed in triplicate. The benzene used was purified as described by Henick, Benca, and Mitchell *(3)*. The extracts were filtered through Whatman No. 1 filter paper, dried by shaking with 1–2 g. of anhydrous sodium sulfate, and refiltered. The final volume of each extract was adjusted to 50 ml. with benzene. The chromatographic tubes had the following dimensions, namely, capillary—1 mm. by 17 mm. (inside diameter); stem—130 mm. long with 7 mm. (inside diameter); reservoir—55 mm. long by 22 mm. (inside diameter) (Cat. No. 7105-GB) and were purchased from Wilkens Anderson Company, Chicago, Illinois. Five ml. aliquots of the benzene extracts were chromatographed. The red color of the alkaline solutions was measured in an Evelyn photoelectric colorimeter (Rubicon Company, Philadelphia, Pennsylvania) with a filter of 420 mμ. Only freshly prepared alcoholic potassium hydroxide was used for color development. Each sample was read within 30 seconds after the addition of the alkali.

Heptaldehyde-2,4-dinitrophenylhydrazone was used as the standard of comparison for estimating the amount of monocarbonyl in the coffee samples. The absorption maximum for this hydrazone in alkaline solution was found in the region of 425 mμ and, therefore, a filter of 420 mμ for use with the Evelyn was considered suitable. The region of maximum absorption in the visible spectrum was determined with the use of a Beckman Model DU Quartz Spectrophotometer and 1-cm. silica cells.

The Evelyn was calibrated by diluting a stock solution of 50 mg. of the standard hydrazone dissolved in 100 ml. of benzene to give concentrations ranging from 5 to 250 micrograms per sample. Five ml. aliquots of each concentration were chromatographed and read in the Evelyn in the same manner as the coffee extracts. A second series of standards was prepared and read without passage through the columns so that proper recovery of the hydrazone could be ascertained.

At storage intervals of 6 and 12 months only, carbonyl was estimated also by the method of Henick, Benca, and Mitchell *(3)* which provides for the simultaneous measurement of saturated and unsaturated carbonyl from optical density readings at 430 mμ and 460 mμ. The benzene extracts of coffee were diluted 1:5 and 5 ml. aliquots of the diluted extract taken for analysis.

Flavor evaluation. Coffee brews were prepared in Silex vacuum coffee makers and served for organoleptic testing according to the procedures described by Lockhart, Tucker, and Merritt *(4)*.

Flavor comparison of brews prepared from coffee stored for 1, 2, 3, 6, and 12 months at the several temperatures was made by single paired tests. Coffee stored at −20° F. was designated as the control, and tests were run accordingly, pairing each of the other storage samples with the control. A moderately large panel, taken at random from personnel of the departmental staff, was instructed to express a preference for one sample of coffee brew in each test, and to rate the brews on the hedonic scale score sheets *(6)* provided.

The tests were conducted in mid-morning and mid-afternoon, at least one hour after meals, and in a special room designed for this type of work.

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[a] Presented at the Seventeenth Annual Meeting of the IFT, Pittsburgh, Pa., May 13, 1957.

[b] Contribution No. 308 from the Department of Food Technology, Massachusetts Institute of Technology.

[c] Present address: Coffee Brewing Institute, Inc., New York, N. Y.

[d] Present address: Ocean Spray Company, Hanson, Mass.

Flavor comparison of brews prepared from coffee stored for 27 months at the several temperatures was made by double paired tests as a limited number of people were available at the time of panel formation. Tests were planned to include several replications in accordance with a randomized block design of Cochrane and Cox *(1)*. The panel was made up of 8 members with 1 or 2 alternates who were given the benefit of participation in a preliminary series of tests on the same storage samples.

The brews were rated on hedonic scale score sheets as before. Crackers were provided in this case for tasting between pairs.

RESULTS AND DISCUSSION

Data obtained for vacuum measurements on coffee stored from 1–27 months at the several temperatures are presented in Table 1. Vacuum in the cans was observed to decrease with increasing temperature of storage and length of storage, but tended to reach an equilibrium at approximately one year of storage time.

The effect of storage temperature on volatile monocarbonyl remaining in the ground coffee over a period of 27 months is shown in Figure 1. Volatiles as volatile monocarbonyl decreased with length of storage over a period of one year. The higher the storage temperature, the greater was the loss of monocarbonyl from the coffee. There was a decrease in rate of loss of monocarbonyl content during the 6 to 27 months' period at all storage temperatures as compared with the rate of loss duriag the first 6 months. This leveling off effect would seem to indicate an approach of minimum loss of monocarbonyl for a given temperature and length of time. It is possible that this is due to a state of equilibrium between volatiles given off from the coffee to the can atmosphere and volatiles adsorbed on the coffee from the can atmosphere.

Data for total carbonyl *(3)* measured after storage intervals of 6 and 12 months only, showed for the 3 lowest temperatures (−20° F., 36–40° F., and 68° F.) a range of 50.8, 51.5, and 49.6 micromoles per gram, respectively, for 6 months, and a range of 50.5, 51.3, and 48.0 micromoles per gram, respectively, for 12 months. These data indicated that no significant changes had occurred during this time interval. Total carbonyl for coffee stored at 99° F. was lower than for the above temperatures, and showed 46.5 and 44.0 micromoles per gram for the 2 storage intervals. The saturated component was higher than the unsaturated

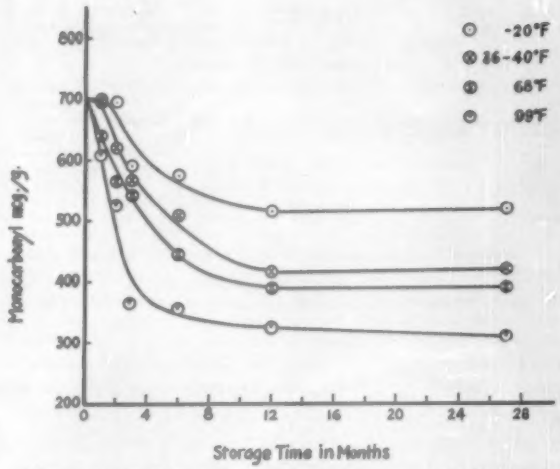

Figure 1. Effect of storage temperature on volatile monocarbonyl in vacuum-packed coffee over a period of 27 months.

in every case, and represented two thirds of the total carbonyl.

The effect of storage temperature on flavor as shown by average scores in paired tests of coffee brews in which samples stored at temperatures of 36–40° F., 68° F., and 99° F. were judged against the −20° F. control sample is presented in Table 2. It was found that the scores obtained at intervals of 1, 2, 3, 6, and 12 months with the panel averaging 25 judges were generally lower than those obtained for the interval of 27 months with the panel of 8 judges.

Average scores in double paired tests of coffee brews after 27 months are presented in Table 3. Average scores of 3 replications were lower for the second pair than for the first pair (tasted in the same panel session). However, the average scores for both pairs (6 replications of one storage sample) checked very closely with the isolated scores for storage samples vs. control (Table 3, last 2 columns).

The higher average scores shown in Table 2 for the 27-month interval represent judgments by 8 regular panel members who had had the benefit of previous training with the same samples and method and the use of several replications, namely, 3 per pair or 6 in

TABLE 1

Periodic vacuum measurements on coffee stored at several temperatures

Time in Months[2]	Average[1] vacuum gauge readings in inches of mercury at:			
	−20° F.	36–40° F.	68° F.	99° F.
1	11.8	10.5	7.8	5.7
2	11.6	8.9	6.6	3.7
3	11.4	8.5	5.6	3.8
6	11.4	8.7	5.1	3.3
12	10.0	7.8	5.2	2.7
27	10.7	5.5	4.6	2.6

[1] Readings represent averages for 6 cans, excepting averages for 3 to 5 cans at 27 months.

[2] Cans removed from storage and equilibrated 24 hours at 68° F. before testing.

TABLE 2

Average scores in paired tests of coffee stored at several temperatures

Time in Months	Sample Pairing I[1]		Sample Pairing II[1]		Sample Pairing III[1]	
	−20° F.	36–40° F.	−20° F.	68° F.	−20° F.	99° F.
1	5.15	5.30	5.13	5.17	4.74	5.61
2	4.93	4.71	4.56	4.61	5.07	5.43
3	4.52	4.68	4.92	5.00	4.28	4.83
6	5.26	5.74	5.32	5.61	4.36	4.64
12	5.60	5.88	4.44	5.24	4.24	4.76
27[2]	6.38	6.88	6.38	6.50	5.63	6.13
27[3]	5.25	6.63	5.38	5.75	6.25	6.38
27[4]	5.82	6.76	5.88	6.13	5.94	6.26

[1] One pair, containing −20° F. control, presented in single test to group of 18–30 people.

[2] Scores for samples of first pair in randomized blocks, by 8 selected judges.

[3] Scores for samples of second pair in randomized blocks, by same 8 judges.

[4] Scores representing averages of [2] and [3] entries.

TABLE 3

Average scores in double paired tests of coffee after 27 months

Temperature of Storage	1st Pair[1]	2nd Pair[1]	Average[2]	Score vs. Control[3]
−20° F.	6.13	5.63	5.88	5.88
36–40° F.	6.42	6.04	6.23	6.76
68° F.	6.62	5.33	5.98	6.13
99° F.	6.24	5.96	6.10	6.26

[1] Average of 3 replications, each treatment judged with every other storage treatment.
[2] Average of 6 replications from simultaneous paired tests.
[3] Entry 27[4] from Table 2, pairing each treatment with control only.

combined pairs. The data in Table 2 for storage periods of 1 to 12 months represent judgments of single panel sessions made by panels of variable membership from day to day and from one storage interval to another. Therefore, it would seem that the data in Table 3 for the 27-month storage period are more reliable for the study of the temperature effect.

In regard to preference, there were no significant differences in numbers of judges who preferred any given sample in any test conducted over the period from 1 to 12 months.

Considerable fluctuation of scores in both Table 2 and Table 3 have made it difficult to decipher any definite trend in flavor quality of the brews with respect to time and temperature of storage of the coffee used.

A simple analysis of variance was applied to the data on coffee stored for 27 months at the several temperatures *(8)*. Total panel scores (not averaged scores) were used, with treatments (storage temperature) and individuals (general experimental error) considered as sources of variation. Calculation of the F-ratio showed that variation in flavor scores due to temperature of storage was slightly less than that due to general sources of error.

SUMMARY

The effect of storage temperature and length of storage on can vacuum, volatiles as monocarbonyl remaining in the ground coffee, and flavor acceptance in the brew, has been investigated in vacuum-packed coffee over a period of 27 months.

Vacuum in the cans and volatile monocarbonyl remaining in the grounds were observed to decrease with increasing temperature of storage and length of storage but tended to reach an equilibrium at approximately one year of storage time. This would seem to indicate that a state of equilibrium was being established between can vacuum and volatiles.

Flavor comparison of brews prepared from the stored coffee samples indicated that no significant change had occurred with time and temperature of storage. Statistical evaluation of flavor scores at 27 months by analysis of variance showed no significant variations due to temperature of storage.

Acknowledgment

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Consumer Preference Studies on Apple Sauce: Sugar-Acid Relations[a]

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IN THE MANUFACTURE of canned apple sauce, two of the most important variables affecting the flavor of the product are sugar content and acidity. Of these two variables, the first—the sugar content—may be accurately controlled by the manufacturer by adjusting the amount of sugar added to the mix. The second variable, the acidity, is, in practice, largely not controlled, although it may be regulated to a certain extent by adjusting the distribution of varieties going into the blend. (For instance, if acid varieties are available only in the early part of the season, they may be stored, and utilized when most needed.) In any case, most manufacturers would find it difficult to maintain the acidity of their apple sauce within sharp limits, even if they could be sure what would be an optimum value.

Experience has shown that in the preparation of fruit juices and of naturally and artificially flavored beverages, maintenance of an optimum sugar-acid ratio is important *(3)*, not only for producing the proper sensation on the taste buds, but for bringing out the olfactory element in flavor. For instance, an increase or decrease in acidity may not be noticed as an increase or decrease in sourness, but as an off-flavor or a lack of flavor. It may be supposed that these observations would be equally true in the case of apple sauce. It is well known that good flavor in apple sauce is most often associated with relatively high acidity, and that sauces made from varieties of apples low in acid are insipid in flavor *(2)*, but no actual data have been available to show how consumer preferences are affected by altering the sugar-acid relations in a given product. The present paper is an attempt to throw some light on this subject.

EXPERIMENTAL PROCEDURES

Survey of commercial brands. A preliminary survey of 13 brands of commercially packed apple juice showed the following ranges of values: Brix (by refractometer), 16.6° to 23.4°, with a mean of 19.3°; pH, 3.40 to 3.70, with a mean of 3.56; total acidity (as malic acid), 0.308% to 0.515%, with a mean of 0.388%; and Brix-acid ratio, 37.8 to 62.1, with a mean of 50.6. Brix values and acidity were not significantly correlated, indicating either that the manufacturers of the sauces examined do not attempt to control the sugar-acid relationships of their products, or that they are not agreed as to what constitutes an optimum Brix-acid ratio.

Acidity and sugar adjustment of samples. A sample of a typical commercial apple sauce for use as a control was obtained from a plant in southern Pennsylvania. The blend was made up of equal proportions of Grimes Golden, Jonathan, Golden Delicious and Northern Spy apples. This sauce had a Brix reading of 17.9°, a pH of 3.42 and a total acidity of 0.393%. To prepare samples containing less sugar than the control, several cans of a dietetic-type pack containing no added sugar were obtained. This sauce was prepared on the same day as the control. It was made from a similar blend and was similar in pH and in acidity (taking into account the diluent effect of added sugar in the control), but gave a Brix reading of only 10.1°.

Since two variables were to be considered, *viz.*, sugar content and acidity, it was decided to present the samples in groups in which one of these factors would be held constant and the other varied by regular increments. The increments chosen were 2% for the sugar content and 0.05% for the acidity. Samples containing more sugar than the control were prepared by adding dry sucrose to the control and mixing thoroughly. Samples containing less sugar were prepared by mixing a calculated quantity of the dietetic pack with the control. Samples containing more acid than the control were prepared by adding the desired amount of acid in the form of a concentrated solution. Citric acid was used for this acidification, since it is inexpensive and readily available. However, the amount added was adjusted so as to be equivalent to the stated quantity of malic acid. Samples containing less acid than the control were prepared by adding a calculated amount of 1 *N*. sodium hydroxide and mixing thoroughly.

Flavor evaluation procedure. Each group of samples was presented to a panel of 100 tasters, consisting of employees of the Eastern Regional Research Laboratory. Makeup of the panel changed somewhat from test to test, but a majority of the members participated in most or all of the tests. Tasters were given no training, and no information about the samples. They were asked to rank the samples on the basis of preference. Four samples were offered in each test, and presented in random order. Code letters for the samples were chosen at random, but were reversed midway in each test in order to reduce the effect of code-letter bias. Each taster recorded the code letters of the 4 samples in order of preference. When a taster was unable to choose between two or more samples, which happened occasionally, he was asked to make a guess.

RESULTS

Results of the tests were recorded by adding the number of first choices, second choices, etc., for each sample in a group. In evaluating the results, 4 points were assigned to each first choice, 3 to a second choice, 2 to a third choice, and one to a fourth choice. This system has the advantage of giving a total value which is a positive function of the degree of preference, and which is also capable of being subjected to analysis of variance.

In the first test, the sugar content remained constant (17.9° Brix) and additions of 0.05%, 0.10% and 0.15% acid were made. Results of the test, shown in Table 1, seem to indicate that the addition of acid to the sauce resulted in a progressive decrease in the degree of acceptance. However, when the results were analyzed by Duncan's multiple range test *(1)*,

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pa., May 14, 1957.

[b] A laboratory of the Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

TABLE 1

Evaluation of apple sauce samples
No added sugar (17.9° Brix)

	Amount of added acid			
	None	+0.05%	+0.10%	+0.15%
Acidity	0.393%	0.443%	0.493%	0.543%
Brix-Acid Ratio	45.5	40.5	36.5	33.2
Number of:				
first choices	36	24	21	19
second choices	26	27	27	20
third choices	15	31	27	27
fourth choices	23	18	25	34
Total Score	275	257	244	224

Differences below 5% level of significance

the differences were shown to be below the 5% level of significance.

In the second test, 2% of additional sugar was added to all of the samples, and the acidity was varied as before. In this case (Table 2), the addition of 0.05% of acid gave the highest score, but the differences were again below the 5% level of significance.

TABLE 2

Evaluation of apple sauce samples
2 per cent added sugar (19.9° Brix)

	Amount of added acid			
	None	+0.05%	+0.10%	+0.15%
Acidity	0.393%	0.443%	0.493%	0.543%
Brix-Acid Ratio	50.6	45.0	40.6	36.9
Number of:				
first choices	25	21	25	29
second choices	34	41	19	16
third choices	35	26	29	20
fourth choices	26	12	27	35
Total Score	248	271	242	239

Differences below 5% level of significance

In the third test, a sauce containing 2% less sugar (15.9° Brix) than the standard was prepared by mixing the standard sauce with the low-sugar dietetic pack. The acidity was varied by adding acid or by neutralizing part of the acid. As shown in Table 3,

TABLE 3

Evaluation of apple sauce samples
Minus 2 per cent sugar (15.9° Brix)

	Amount of added acid			
	−0.05%	None	+0.05%	+0.10%
Acidity	0.343%	0.393%	0.443%	0.493%
Brix-Acid ratio	46.4	40.5	36.0	32.5
Number of:				
first choices	35	31	18	16
second choices	18	37	31	14
third choices	25	19	35	21
fourth choices	22	13	16	49
Total score	266	286	251	197

Differences below 5% level of significance

the control sample gave the highest score, but although the differences were greater than before, they were still below the 5% level of significance.

In the fourth test, no acid was added to the samples, but the sugar content was varied by 2% increments. As shown in Table 4, a significant preference was shown for a sauce containing 2% added sugar.

In the fifth test, 0.05% acid was added to all the samples, and the sugar content again varied in the same manner as above. As shown in Table 5, the

TABLE 4

Evaluation of apple sauce samples
No added acid, Brix variable

	Amount of added sugar			
	−2%	None	+2%	+4%
Brix value	15.9°	17.9°	19.9°	21.9°
Brix-Acid ratio	40.4	45.5	51.7	58.0
Number of:				
first choices	17	18	37	28
second choices	14	25	33	28
third choices	20	37	22	21
fourth choices	49	20	8	23
Total score	199	241	299	261

Differences above 5% level of significance

preferred sample was the one containing 4% added sugar, a majority of the tasters giving it as their first choice. The differences were significant at the 5% level.

SUMMARY AND CONCLUSIONS

In general, the higher the acid content of a sauce, the higher was the sugar content required for the optimum flavor effect. However, the optimum Brix-acid ratio was not the same in all tests. Changes in sugar content affect the degree of preference to a greater extent than proportionally equivalent changes in acidity.

The data indicate that the sauce preferred by most tasters was one containing about 0.45% acid, with a Brix value of about 22, that is, with 0.05% more acid

TABLE 5

Evaluation of apple sauce samples
0.05% added acid

	Amount of added sugar			
	−2%	None	+2%	+4%
Brix value	15.9°	17.9°	19.9°	21.9°
Brix-Acid ratio	35.9	40.4	45.9	51.4
Number of:				
first choices	6	18	22	54
second choices	19	17	40	24
third choices	23	40	26	11
fourth choices	52	25	12	11
Total score	179	238	272	321

Differences above 5% level of significance

and 4% more sugar than the standard sauce chosen for the tests.

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Sorbic Acid as a Selective Agent for Cucumber Fermentations

III. Evaluation of Salt Stock from Sorbic Acid Treated Cucumber Fermentations [a, b, c]

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The literature regarding the importance of yeast activity in cucumber fermentations and the inhibition of microorganisms by sorbic acid has been adequately reviewed in two previous reports from this laboratory *(4, 5)*. Briefly, gaseous fermentations by yeasts are responsible for large economic losses in brine cured cucumbers due to bloater (hollow cucumber) formation. Sorbic acid inhibits the growth of yeasts, molds, and many bacteria, but does not greatly affect the lactic acid bacteria or the clostridia.

The purpose of this entire study was to determine whether sorbic acid would inhibit yeast activity in cucumber fermentations without inhibiting acid fermentation; and, in this manner, prevent bloater spoilage without interfering with the curing of the cucumbers. It has been found *(4)* that no significant yeast fermentations developed in brines treated with sorbic acid in concentrations of 0.025 to 0.1%. Acid development was inhibited markedly by 0.1% sorbic acid and, also by 0.05% in fermentations brined at 40° salometer. Lower levels of sorbic acid had no significant effect on acid development.

Borg *et al. (1)* reported that bloater spoilage was reduced from 60% in control lots to less than 5% in lots treated with 0.1% sorbic acid. However, this treatment inhibited acid fermentation greatly and the resultant salt stock was found to be inferior in cure and color.

The present study was made to determine the effectiveness of various sorbic acid treatments in reducing bloater spoilage of salt stock and to evaluate the effect of such treatments on the cure, color, and firmness of the stock.

MATERIALS AND METHODS

The distribution, brining procedures, and methods of treatment of most of the experimental cucumber fermentations used in this study were described by Costilow *et al. (4)*. Two replications were run in 1955 on which microbiological studies were not conducted but an evaluation of the salt stock was made. One of these was brined at 30° and one at 25° salometer. Two replications involving oversize (2 to 2⅛ in. diameter) cucumbers brined at 20° salometer in 1956, were not included in this report. This report covers the evaluation of 17 replications of each of 3 sorbic acid treatments for 1954, 12 replications of each of 4 sorbic acid treatments for 1955, and 8 replications of each of 3 sorbic acid treatments in 1956. Thus, the evaluation of salt stock from 123 experimental fermentations is reported here.

The first examination of the salt stock was made within 3 to 4 months after salting. If curing was nearly complete, the final evaluation was made. If not, the stock was reexamined 3 to 5 months later. Barrel lots were all sampled with a net. Samples from the larger lots were removed by use of a sampling device recommended by Etchalls *(7)* except for a

[a] Journal article No. 2075.

[b] The study was supported financially by a grant from The Carbide and Carbon Chemicals Company, 30 East 42nd Street, New York 17, New York.

[c] Presented before the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 13, 1957.

few tanks which were packed so tightly that it was necessary to use a net. In all instances, part of each sample came from the bottom, center and top layers of each tank.

Two hundred cucumbers were counted out of each sample, and cut longitudinally. The cut stock was graded for percent cure, color, and percentage of various types of bloaters. Percent cure was determined by estimating the approximate percentage of the tissue showing the white color of raw tissue and subtracting this value from 100. Visual observations were made for any color variations. The bloaters were divided into the categories of "severe," "small separations" and "poor seed cavities." These 3 types of bloaters are represented in Figure 1. In 1956, still another type of bloater was enumerated—the lens. This type is characterized by lens-shaped separations *(8)*. In the 1954 and 1955 evaluations, the lens bloaters were included in the small separation classification.

Firmness was measured on a number of the lots of salt stock by use of a U.S.D.A. Fruit Pressure Tester. Ten pickles of uniform size and shape and free of bloaters were selected from each lot, laid on a flat surface, and a single punch made in the center of the pickle.

RESULTS

The percentage of all types of bloater spoilage except the small separations was reduced very greatly by sorbic acid treatment (Table 1). In 1954 and 1955, when the lens-type bloaters were included in the small separation category, the percentage of small separations in the treated lots was less than in the control. However, in the 1956 experiments, the percentage of small separations was higher in the treated lots than in the controls. These differences are not believed to be significant.

Although the occurrence of severe bloaters and poor seed cavities was reduced by the 0.01% sorbic acid treatment, it was not to the extent noted with treatments of 0.02 to 0.1%. Thus, while the average percentage of severe bloaters in the 1955 experiments with 0.01% sorbic treatment was only about 60% of the control, less than 20% of the control spoilage occurred in the 0.025 and 0.05% sorbic acid treatments. A similar relationship was noted with poor seed cavities.

Increasing the sorbic acid level from 0.02 to 0.1% had no significant effect on bloater control. Therefore, a better estimate of the effect of sorbic treatment is obtained by averaging the data from all 3 years. This summary is shown in Table 2. The percentage of severe bloaters and poor seed cavities in salt-stock from fermentations treated with sorbic acid at levels of 0.02 to 0.10% was less than one-fourth of that in the controls. The total bloater-type spoilage was reduced by about two-thirds with sorbic acid, and the spoilage other than small separations was reduced more than three-fourths.

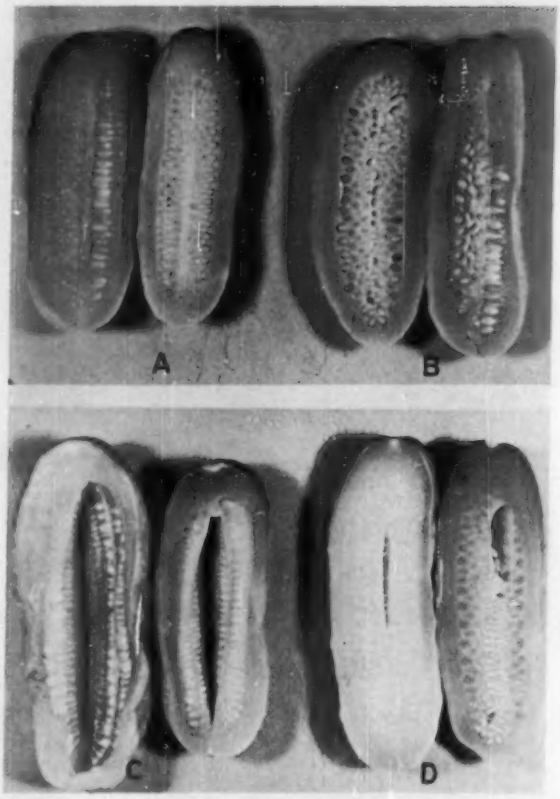

Figure 1. Classifications of bloater-type spoilage: A. sound stock, B. poor seed cavities, C. severe bloaters, and D. small separations.

Sorbic acid treatments were found to slow the curing rate of brined cucumbers in a number of instances. As may be noted in Table 3, the curing was more frequently affected in fermentations brined at high salt levels than at low. When the cure was affected by any sorbic acid treatment of a given replication, it was usually affected by all treatments. How-

TABLE 1

Effect of sorbic acid treatments on the occurrence of bloater-type spoilage

Type of spoilage	Season	Percent spoilage with various treatments[1]					
		Controls	Percent sorbic acid				
			0.01	0.02	0.025	0.03	0.05	0.10
Severe bloaters	1954	8.1	...	...	...	...	2.7	1.8
	1955	7.3	4.4	...	1.3	...	1.3	...
	1956	9.8	...	2.6	...	0.8	...	...
Small separation	1954	9.3	...	...	...	...	4.6	6.0
	1955	9.5	7.0	...	6.2	...	3.8	...
	1956	7.7	...	10.8	...	9.1	...	...
Poor seed cavity	1954	10.4	...	...	...	...	1.8	1.5
	1955	17.9	10.6	...	5.8	...	3.6	...
	1956	6.1	...	0.9	...	0.6	...	...
Lens	1956	2.9	...	0.9	...	0.6	...	...
Total spoilage	1954	27.8	...	...	...	...	9.1	9.3
	1955	34.7	22.0	...	13.3	...	8.7	...
	1956	26.5	...	15.2	...	11.1	...	...

[1] These data represent the means for 17 fermentations per treatment in 1954, 12 in 1955, and 8 in 1956.

TABLE 2

Average bloater-type spoilage for all three years

Type of spoilage	Percent spoilage with various treatments[1]		
	Controls	Percent sorbic acid	
		0.01[2]	0.02–0.10
Severe bloaters	8.4	4.4	1.8
Small separation	8.8	7.0	6.8
Poor seed cavity	11.5	10.6	2.4
Lens[3]	2.9	....	0.8
Total spoilage	30.6	22.0	11.8
Total spoilage minus small separation	21.8	15.0	5.0

[1] Averages of means for each year.
[2] Based on 1-year's data.

ever, the degree of the effect increased greatly as the percent of sorbic acid used increased. This can be noted in Figure 2. All 3 replications illustrated were brined at the same salting station using the same variety of cucumbers, and with an initial salt strength of 25° salometer brine. No influence of any of the sorbic acid treatments on the curing rate was noted with the replications brined Aug. 7 to 9 and Aug. 20 to 21. However, all treatments used affected the rate of cure of the stock in the fermentations brined between Aug. 29 and Sept. 1. The delay in cure was greater as the sorbic acid concentration increased.

In some instances, the salt stock from sorbic acid treated fermentations had a very unusual appearance. The interior tissue of the pickles had a bleached or "washed out" appearance. In some of the more severe cases, this was observed on the skin of the stock. This is illustrated by the slice of salt stock from a fermentation treated with 0.05% sorbic acid shown in Figure 3.

This bleaching was not evident in all fermentations even when the 0.1% sorbic acid treatment was used. However, the higher the sorbic acid treatment the more frequently it was noted and the more pronounced the bleaching appeared. It was noted in many instances when a 0.1% treatment was used and in a number of instances when 0.05% sorbic acid was used. However, no significant bleaching with lower concentrations was noted except in two replications with both 0.02 and 0.03% sorbic treatments. These two replications were studied in 1956 at the same salting station. They were all in indoor tanks and were salted at 32° salometer initially. No appreciable bleaching of salt-stock was noted at the first examination made 4 months after brining, but severe bleaching was evident on reexamination 4 months later.

Firmness of the salt stock was not greatly influenced by sorbic acid treatment of fermentations. Average differences shown in Table 4 are so small and the variations of individual measurements were so great, that no significance is attached to them.

TABLE 3

Effect of sorbic acid on the curing of cucumbers with various brining treatments

Sorbic acid treatment	Fermentations	Initial salometer at brining		
		20–25°	30–34°	37–40°
%				
0.01	No. affected[1]	0	2	1
	No. studied	5	5	2
0.02–0.03	No. affected	4	4	1
	No. studied	17	9	2
0.05	No. affected	1	4	3
	No. studied	10	11	8
0.10	No. affected	0	2	3
	No. studied	5	6	6

[1] The cure was considered to be affected when the percent cure of the stock in the treated tanks was at least 10 percent less than that in the control.

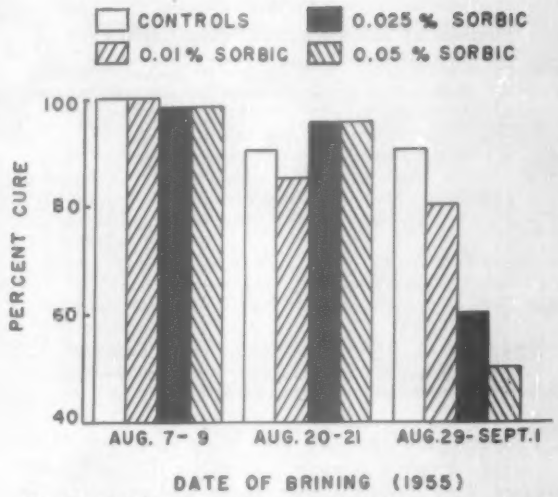

Figure 2. Effect of sorbic acid treatments on the curing of cucumbers brined at various periods of the season.

DISCUSSION

There is no question but what the control of yeasts by sorbic acid treatment will reduce the percentage of bloater spoilage of the salt-stock in cucumber fermentations. The percentage of spoilage classified as severe, poor seed cavities, and lens-type bloaters was reduced to a very low level. Therefore, such spoilage must be due primarily to yeast fermentations. However, the percentage of small separations was not greatly affected by sorbic acid treatment; and, therefore, may not be primarily due to yeast activity. The author has observed this type of separation of the carpels in raw cucumbers of this variety (SR-6) and size (1½ to 2 in. diameter) before salting. Although it has never been observed in the raw cucumbers at as high a percentage as observed in the salt stock, the fact that it does occur indicates that large cucumbers of this variety are very susceptible to this type of separation. It would appear reasonable that the osmotic influence applied on the cucumber on immersing in brine might be sufficient to cause such small separations.

Figure 3. Salt stock from various sorbic acid treatments showing bleaching at the 0.05 per cent level of sorbic acid.

TABLE 4

Firmness of salt stock from various treatments

Season	No. of replications tested	Sorbic acid treatment	Average pressure test[1]
			lbs.
1954	11	Controls	23.0
		0.05%	23.7
		0.10%	24.0
1955		Controls	15.1
		0.01%	15.5
		0.025%	15.7
		0.05%	16.3
1956	4	Controls	15.1
		0.02%	15.4
		0.03%	15.9

[1] All pressure tests were run with a U. S. D. A. fruit pressure tester. A 5/16 in. tip was used in 1954 and a 7/16 in. tip in 1955 and 1956.

However, the fact that there was a small percentage of severe bloaters always present in the sorbic acid treated lots indicates that there are other factors involved in such spoilage. Borg *et al. (2)* observed that *Lactobacillus brevis*, a gas-producing organism, would cause bloat in pasteurized cucumbers. Also, they observed that serious bloater spoilage occurred in overnight dill pickles in which yeast growth was inhibited by sorbic acid. These brines contained high populations of *L. brevis*. Since the presence of *L. brevis* in cucumber fermentations has been demonstrated a number of times *(2, 3, 9, 10)*, it is possible that this organism is responsible for some bloater spoilage of salt stock.

The rate of curing of cucumbers for salt stock is very important to the industry. Many salters have started to use lower salting schedules in order to get more rapid curing. Therefore, the delay of curing by sorbic acid constitutes a major objection to its use. These data show that curing is not often affected when low salt concentrations are used for the initial brines. However, in one replication where the cucumbers were brined late in the season, 0.025% sorbic acid greatly delayed the curing of cucumbers in 25° salometer brine. Therefore, it is indicated that the temperature of the brine may play an important role in determining the effect of sorbic on curing. If this is true, this problem should not be serious in southern areas where the crop is brined much earlier in the season. However, Borg *et al. (2)* found that 0.1% sorbic did affect the cure of stock which had been brined at 9.15 to 15% salt (35 to 60° salometer).

The other major problem encountered with sorbic acid treatment of cucumber fermentations was the bleaching of the salt stock. The fact that it occurred sporadically indicates that there are factors other than the presence of sorbic acid which are involved. Bleaching did occur more frequently with the higher sorbic levels used but it was observed in some instances with treatments ranging from 0.02 to 0.10%. It was not observed in any of the lots fermented in 1955 in which 0.01 and 0.025% treatments were used. These data give no indication of what other factor(s) may be associated with this bleaching.

An explanation of the bleaching by sorbic acid treatment is not yet available. However, it is known that chlorophyll may be either oxidized or reduced to colorless compounds *(11)*. Both of these reactions are apparently reversible since a green colored pigment may be produced by subjection to the opposite reaction. Eisenstat and Fabian *(6)* have shown that pickles are bleached by either oxidizing or reducing agents. It is reasonable that sorbic could act as an oxidizing agent by accepting hydrogen. However, this remains to be proven.

Preliminary experiments have indicated that the bleaching caused by sorbic acid is not a serious problem in processed pickles. No off-color was noted in either whole dills or hamburger dill slices processed from bleached salt stock. However, insufficient data are available with respect to the development of color and the effect of storage on the color of these pickles to present any conclusions at this time.

SUMMARY

A study of the salt stock from 123 experimental cucumber fermentations involving sorbic acid treatments from 0.01 to 0.10% has been completed. Sorbic acid treatments of the fermentations reduced the occurrence of bloater-type spoilage of the salt stock greatly. The occurrence of large pockets (severe bloaters) and of loose seed (poor seed cavities) was reduced by approximately 75%. However, the incidence of small separations was not changed significantly by sorbic acid treatments.

No significant differences in bloater control were noted with sorbic acid treatments ranging from 0.02 to 0.10%. However, it was apparent that 0.01% was not as effective.

All levels of sorbic acid tested delayed the curing of the salt stock. This was more frequent in fermentations brined at a high salometer than at low salometer. Also, the effect on curing was noted more frequently when the temperature of fermentation was lower. When a delay in cure by sorbic acid was observed, it was usually found with all sorbic treatments of the replication. However, the degree of the delay was greater with increasing sorbic acid concentrations.

Bleaching of salt stock was frequently noted in fermentations treated with 0.1% sorbic acid and occasionally with 0.05%. Also, this was observed at one location in duplicate lots of each 0.02 and 0.03% sorbic acid. Preliminary observations indicate that this is not a serious problem since no off-color of processed pickles made from such stock was evident. However, further investigation of this is needed.

There was a trend which indicated that the firmness of the salt stock increased with sorbic acid treatment. However, the differences noted were too small to be of much significance.

Acknowledgment

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Factors Affecting the Consistency of Cream Style Sweet Corn[a, b]

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(Manuscript received May 15, 1957)

THE CONSISTENCY of canned cream style sweet corn made from whole kernels which have been washed, rinsed, screened, and inspected after cutting, and which are without cob scrapings (frequently referred to as cremogenized corn) is controlled by the proper blending of raw corn, water starch, sugar, and salt. The study of cream style corn consistency might be considered a problem of rheology. The basis of rheological studies is the definition of viscosity which is considered resistance to flow or, more particularly, as the shearing stress divided by the rate of shear.

This flow problem is particularly important to the corn packing industry because consistency is allotted 20 out of 100 points in the U. S. Standards for grades of canned cream style corn *(5)*. It is a limiting rule in the standard and sub-standard ranges. This means canned corn falling into these classifications cannot earn higher grade regardless of total score.

Cream style corn is a corn-water-starch system, water being the important carrying agent in which the other ingredients are dissolved or dispersed. Changes in the physical properties of this system are brought about by the action of hydrophilic colloids. In cream style corn the polysaccharide starch, which is a non-electrolyte, is the most important. Starch is blended into the system from two sources (a) as an integral part of the corn itself (about 11%), and (b) as a direct additive. Both sources have an important effect on the final consistency of the product.

The objects of this two year investigation were:

1. To predict the processed consistency of the cream style corn after 1, 3, 6, and 12 months storage from the consistency at the filler using commercially acceptable manufacturing methods.

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

[b] Scientific Article A629. Contribution No. 2811 of the Maryland Agricultural Experiment Station (Department of Horticulture).

2. To develop a nomograph which can be used to predict the consistency of the cream style corn after 90 days storage, from the various proportions of added starch, starch in the cream component and water at the start of blending.

EXPERIMENTAL

Raw materials. Tendermost and Victory Golden varieties of golden sweet corn were used interchangeably in this work for either the cream or kernel component in the manufacture of cream style corn. The starch added was Clinton canners starch, a regular corn starch. Westminster city water, and regular canners sugar and salt were used in preparation of the product.

Procedure for making cream style corn. *1955 season.* The product was prepared and processed at a commercial cannery as a blend of macerated kernels (kernels not completely ruptured), washed whole kernels which are completely ground into a cream, water, starch, salt and sugar.

In the experimental procedure, samples of unwashed corn going into the kernel portion, and into the cream portion were brought to the laboratory for maturity tests using the succulometer *(2)*.

While laboratory samples were being checked, the corn for the kernel component was made into a medium slurry by a TUC* macerator and the corn for the cream component was ground by the TUC creammaker.

Twelve separate batches of cream style corn were prepared using the prescribed commercial formula for amount of kernel and cream components, sugar and salt. These factors were held constant in weight for each replication. The maturity of the raw corn in both the kernel and cream components varied in the extra standard and fancy range.

The following water levels were used: a. 49.3%, b. 39.2%, c. 30.3%, and d. 20.8% of blend. The water levels were percentages of the combined weight of corn, salt and sugar.

Starch was varied in the total blend as follows: a. .63%, b. .95%, and c. 1.26% of blend. The starch percentages were based on the total blend weight.

Six replications of creamed style corn samples with consistency in the fancy, extra standard, and standard range were canned.

Each starch level was studied in conjunction with each water level in a balanced factorial arrangement with all other factors being held constant except for the maturity of the corn.

The blend was heated with agitation in an open steam jacketed kettle to a closing temperature of 185° F. in about 12–15 minutes depending on the consistency of the batch being produced. At the time of filling the temperature (165° F. average) was recorded and duplicate consistency readings were determined using the Adams consistometer which is a limit of flow technique measuring the base of a spreading mass. This technique has been described as particularly applicable to the viscosity of cream style corn *(1)*.

The contents of the kettle were filled into No. 303C enamel cans and processed for 75 minutes at 240° F. These samples were opened later for the measurement of processed consistency.

1956 season. In 1956 the same sugar, salt and corn proportions were used as in the 1955 work. The range of starch levels were increased to thicken the samples and the 49.3% water level was eliminated because it generally gave a very soupy consistency at all starch levels. Also, samples of the cream and kernel components was weighed into No. 303 cans with 100 ml. H_2O closed and heat processed for later laboratory analyses. In this way samples of corn making up the experimental batches were preserved for later testing.

The following water and starch levels were used:

Water—a. 39.2%, b. 30.3%, and c. 22.8% (percentage combined weight corn, sugar and salt).

Starch—a. .63%, b. 1.26%, and c. 1.89% (percentage total weight).

Five replications of samples using corns of different maturity were evaluated as described under the 1955 procedure.

* The United Company, Westminster, Maryland.

Laboratory analysis. *1955–56.* After room temperature storage (68–76° F.) of 1, 3, 6, and 12 months samples of all replications were evaluated for consistency using the Adams consistometer. The 12 month consistency values for 1956 are not included, because 12 months have not elapsed since the samples were prepared.

Further the 1956 samples were graded by an official inspector of the Agricultural Marketing Service and assigned a consistency grade based on 20 as a top score.

Canned samples which were prepared for laboratory analysis were analyzed for starch and alcohol-insoluble solids (AIS), and a maturity score using the Trimetric system *(4)* was assigned each sample for both the cream and kernel component.

Statistical analysis. Statistical procedures followed were as described by Snedecor *(3)*.

RESULTS AND DISCUSSION

Samples prepared in 1955 were generally less viscous in consistency at the filler and after storage than the 1956 samples. This was in part due to a higher water level in one treatment and lower starch levels in conjunction with more immature corn in both the kernel and cream components.

1955. The correlation coefficients 0.870 to 0.907 for linear values and 0.893 to 0.940 for log transformed values shown in Table 1 between consistency at the time of filling and consistency after storage for 1, 3, and 6 months suggested that a curvilinear relationship existed between filling and storage values. At 12 months a linear relationship existed. Rectification for the shorter storages to linearity was accomplished by taking the logarithm of the storage consistency values and correlating them with filler consistency values. This confirmed the curvilinear relationship for a considerable improvement was obtained in the correlation coefficients. Regression equations calculated from these correlations are as follows:

One month log $Y = .0439\ X + .5695$
Three month log $Y = .0398\ X + .6402$
Six month log $Y = .0440\ X + .6731$
Twelve month $Y = .8570\ X + 3.680$

From these equations the expected consistency (Y) may be predicted from a consistency determination at time of filling (X). Regression lines drawn with these equations are shown in Figure 1. Data in Figure 1 was based on an approximate 15% AIS cream component and an 8.79 average consistency.

1956. In 1956 the results of five replications are reported. The correlation coefficients shown in Table 1 (the second part) between consistency at the time of fillings and consistency after storage for 1, 3, and 6 months suggested a straight line rather than a curvilinear relationship existed between filling and storage values. This was probably due to the reduction of consistency range where neither the extremely thin or extremely thick samples were tested in the 1956, whereas, in 1955, particularly in the thin range, there was a considerable number of samples. The curvilinear relationship appeared at the end of the scale where consistency was thin. Regression equations calculated from these correlations are as follows:

One month $Y = .658\ X + 5.17$
Three months $Y = .569\ X + 6.26$
Six months $Y = .598\ X + 6.07$

From these equations the expected consistency (Y) may be predicted from a consistency determination at the time of filling (X). Regression lines drawn with these equations are shown in Figure 2. The lines show that generally if the corn were thin at the filler there was a longer period required to reach a stabilized consistency while samples thick at the filler would not change much between 30–90 and 180 days. These values were based on a 10.5 average consistency value and a 17.4% average AIS of the cream component.

Comparison of factors affecting consistency. In comparing the factors which affected the processed consistency of cream style corn, water and added starch were varied in a commercial range. The single correlation coefficient between added water and consistency after 90 days was −0.86 and for added starch it was +0.70. It was obvious that not only water and starch (added) were important factors affecting consistency but also the starch from the corn itself had an important function. The problem was whether the cream component, kernel component or both were important in the stabilized consistency prior to shipment. To solve this problem the AIS of both the cream portion and the kernel portion were correlated separately with final consistency. The resulting correlation coefficients were: AIS cream component vs. consistency 90 days + 0.65, AIS kernel component vs. consistency 90 days + 0.28. This indicates that considerably more of the final consistency could be attributed to the cream rather than the kernel component. Considering the method of handling the cream component (completely ground) and the fairly intact kernels in the kernel component it can logically be seen more starch would be released in the former than the latter for setting up final consistency.

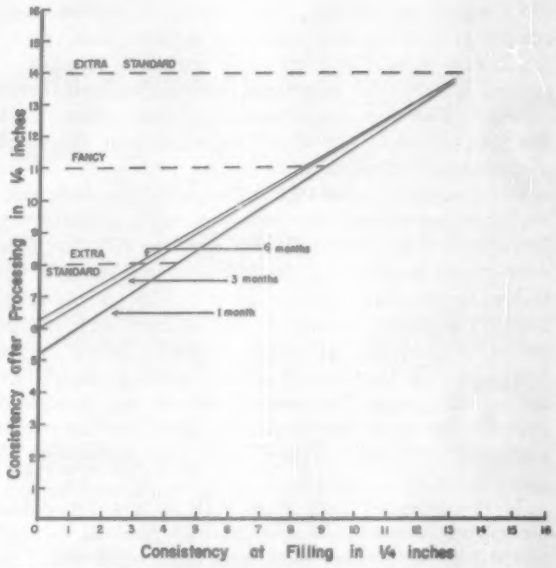

Figure 2. The consistency of cream style corn after processing and storage as predicted from consistency at time of filling (determined by the Adams Consistometer) 1956.

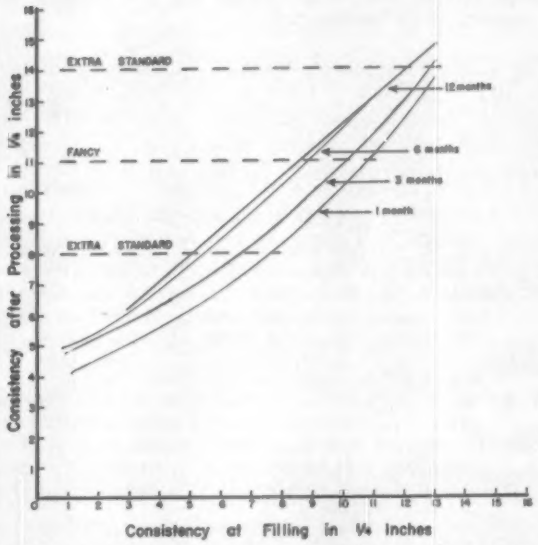

Figure 1. The consistency of cream style corn after processing and storage as predicted from consistency at time of filling (determined by the Adams Consistometer) 1955.

Nomograph to predict consistency after 90 days storage. Since there was an obvious difference between filler consistency and processed product consistency after storage between the 1955 and 1956 seasons it was decided to construct a nomograph which would be applicable under varying conditions. The nomograph (Figure 3) was constructed from the 3 factors studied which influenced processed consistency to the greatest extent. They were water added

TABLE 1

Correlation coefficients between cream style corn consistency at filling and after storage as determined by the Adams Consistometer

1955

Factor	Processed consistency after storage							
	1 month	log of 1 month	3 months	log of 3 months	6 months	log of 6 months	12 months	log of 12 months
Consistency at filling	.870	.937	.893	.940	.885	.936	.907	.893

1956

Factor	Processed consistency after storage					
	1 month	log of 1 month	3 months	log of 3 months	6 months	log of 6 months
Consistency at filling	.900	.899	.918	.907	.862	.878

(W), starch added (S), and AIS of the cream component (C). This AIS was 67% starch. The AIS of the kernel component was not included because it showed a very low relationship with processed consistency. The nomograph would be used to determine the proportion of the above ingredients at the start of blending.

For construction of the nomograph the following multiple regression equation was used: consistency 90 days = 5.44 − .143 W + 1.18 S + .471 C. This nomograph is based on the 1956 experiment and the following average figures: 17.4% AIS cream component, 25.3 succulometer value of raw corn in the cream component, trimetric maturity score cream component 36.4 out of 40 and as AMS score of 17.6 out of 20 points for consistency of the processed product—most of the samples rated in the extra standard and fancy range from the standpoint of consistency.

It is suggested that since AIS is a lengthy test succulometer values of raw corn be used as a quick method to determine AIS and thus be a guide in determining set after 90 days. Succulometer values could be substituted for AIS values on the nomograph scale if necessary. Table 2 taken from Kramer and Smith *(2)*, gives the relationship between the succulometer of raw and the AIS of canned kernels.

CONCLUSIONS

Water (r = −0.86), added starch (r = +0.70) and starch in the cream component (r = +0.65) were the factors chiefly responsible for the processed consistency of cream style corn after 90 days storage. Starch in the kernel component had a correlation coefficient of +0.28 with processed consistency.

The relationships between consistency at the filler and processed consistency after 1, 3, 6, and 12 months storage showed correlation coefficients of approximately +0.90. In general, filler consistency values of about 9 Adams (165° F.) gave consistency values after 90 days of around 11.0 which were considered top fancy.

Because of variation between the two seasons' results a nomograph was constructed from the following multiple regression equation: consistency 90 days = 5.44 − .143 W + 1.18 S + .471 C. This nomograph showed that top fancy consistency after 90 days may be reached by any number of combinations of water, and starch, with corn of varying maturity.

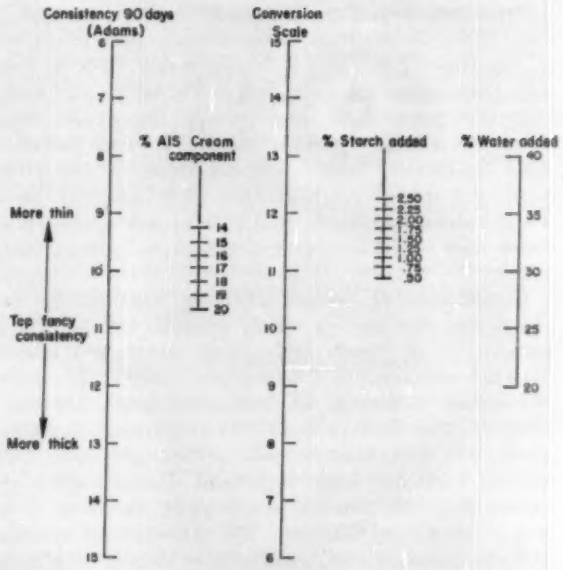

Figure 3. Nomograph for predicting the consistency of cream style corn after processing and storage for 90 days from proportions of water, added starch, and AIS of the cream component in the blending tank.

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TABLE 2

Relative succulometer, moisture, and alcohol insoluble solids values for raw and canned whole kernel brine packed golden sweet corn[1]

Canned kernels		Raw kernels		Maturity rating per A.I.S.
A.I.S.	Succulometer	Moisture	Succulometer	
15.0	23.7	77.9	25.0	Very young (fancy)
16.0	22.9	76.0	24.5	Very young (fancy)
17.0	22.0	74.4	23.8	Very young (fancy)
18.0	21.1	73.0	23.1	Very young (fancy)
19.0	20.2	71.7	22.4	Very young (fancy)
20.0	19.3	70.4	21.7	Young (extra standard)
21.0	18.4	69.0	21.0	Young (extra standard)
22.0	17.4	67.6	20.2	Young (extra standard)
23.0	16.8	66.3	19.0	Young (extra standard)
24.0	15.6	65.1	17.5	Nearly mature (standard)
25.0	14.6	64.0	15.9	Nearly mature (standard)
26.0	13.7	63.0	14.1	Nearly mature (standard)
27.0	12.8	62.0	12.4	Nearly mature (standard)
28.0	12.0	61.0	10.7	Mature
29.0	11.2	60.1	9.1	Mature

[1] Taken in body from Kramer and Smith (*2*).

Freeze-Dried Meat

V. Preparation, Properties, and Storage Stability of Precooked Freeze-Dried Meats, Poultry, and Seafoods[a]

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FOR MILITARY and emergency rations there is need for dehydrated meats which possess good storage stability, which can be prepared in minimum time, and which will have maximum utility and high acceptability *(8)*. Relatively large quantities of ground cooked beef and pork were prepared during World War II and used for military feeding. The methods of preparation and the limitations of these dehydrated meat items are adequately reviewed elsewhere *(5)*. Recent research on dehydrated precooked ground pork shows that browning is the principal deteriorative mechanism and that the quality of the pork can be improved by removal of glucose *(2, 3, 6)*. However, the successful production of raw freeze-dried meat of suitable storage stability and functional properties has focused attention on freeze-drying as the ideal method of dehydrating meat *(1)*. With continued improvement in the freeze-drying process and in the functional properties of the freeze-dried meats and their acceptability, there is every indication that freeze-drying of meat will be technologically and economically sound and the method of choice. In order to decrease the time for preparation of the hot rehydrated meats, precooked freeze-dried meats are desired. Precooked freeze-dried chicken of good functional and organoleptic properties has been prepared *(9)*. As in the freeze-drying of raw meats, heat transfer was the factor limiting the rate of dehydration of precooked chicken.

It is the purpose of this paper to describe exploratory research on the preparation, properties, and storage stability of a wide variety of precooked freeze-dried meat, poultry and seafoods.

EXPERIMENTAL

Cooking and drying. The meat, poultry and seafoods selected for this study are those of greatest economic importance and are listed in Table 1. Approximately 20 pounds of a widely used cut or piece of each meat item was prepared in the sizes given in Table 1. Cooking conditions selected for each food item were chosen to give easily reproduced conditions and to approximate the cooking conditions which might be used in the industrial preparation. Precooked meats, poultry, and seafoods were freeze-dried in a Stokes Model 2004L freeze-dryer with shelf temperatures and absolute pressures corresponding to those given in Table 1. In this freeze-dryer, heat was supplied by warm water circulated through hollow shelves and the absolute pressure was maintained at values less than 0.5 mm. by a positive displacement vacuum pump and a condenser at −30° F. During each freeze-drying operation, the meat, poultry, and seafoods were weighed every 2 hours to measure the rate of freeze-drying and to determine when drying was complete. During some of the freeze-drying operations internal temperatures of the meats were measured with thermocouples.

Two methods of simultaneous cooking and drying were evaluated using beef steak. In the first method, hydrogenated cooking oil was held at 212° F. in a vacuum chamber maintained at 2.5 mm. Two inch cubes of frozen round steak were added to the hot oil. The water which distilled off was collected in a refrigerated condenser. After drying, the meat was centrifuged to remove excess oil. In the second method, steaks were roasted in a vacuum oven at 260° F. and 70 mm. pressure to a final internal temperature of 140° F. After vacuum roasting, the steaks were subsequently freeze-dried.

Measurements of properties. Rehydration expressed as per cent of water content of the precooked meats, poultry, and seafoods was determined for 2 to 10 samples. The samples were submerged in the rehydration liquids listed in Table 2 under atmospheric pressure or 690 mm. vacuum for 15 or 2 min., respectively, and the averages were computed from the values obtained.

The vapor pressure of freeze-dried precooked beef and pork was measured using the apparatus described by Legault *et al. (4)* by methods previously described *(7)*.

Reflectance spectra were measured with a DR Beckman recording spectrophotometer with a reflectance attachment.

Measurement of storage stability. After completion of freeze-drying, samples of the meats, poultry, and seafoods were packed in quart mason jars. Each jar contained either magnesium perchlorate or anhydrous calcium sulfate as in package-desiccant, a packet of activated carbon, and was gassed with pure nitrogen. These samples were then placed in storage at temperatures of 40° F., 70° F., 100° F., and 130° F. and were removed at approximately monthly intervals for rehydration and organoleptic evaluations. The samples were rehydrated 20 min. at atmospheric pressure using the rehydration liquids listed in Table 2. After rehydration, the coded samples were presented to a panel of approximately 10 individuals familiar with the hedonic scoring of meats. Using the hedonic scoring system, the flavor, tenderness, and color were evaluated. Uncooked meats, poultry, and seafoods held in frozen storage served as controls. These organoleptic scores were averaged and graphed as a function of time so that the generalities of storage stability for the various meats, poultry, and seafoods might be determined. The decreases in hedonic scores presented herein were taken from these graphs.

RESULTS AND DISCUSSION

Simultaneous cooking and drying. Because the method of step-wise cooking and freeze-drying is inherently inefficient in heat utilization and is time consuming and expensive, attempts were made to find

[a] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or endorsement of the Department of Defense.

TABLE 1
Cooking and freeze-drying of meats, poultry, and seafoods

Food and description	Size	Cooking conditions	Cooking loss	Freeze-drying plate temp.	Freeze-dryer pressure	Time for drying to 2% water
	inches		%	*° F.*	*mm. Hg.*	*hours*
Beef 1, top round steaks	4 x 2½ x ⅝	Oven-broiled at 450° F. to 160° F. internal temp.	26	106	0.16	18
Beef 2, top round steaks	6 x 3½ x ⅝	Oven-broiled at 450° F. to 160° F. internal temp.	31	104	0.22	18
Beef 3, top round steaks	4 x 3½ x ¾	Cooked at 10 p.s.i., 12 min.	45	100	0.13	16
Pork 1, loin and rib chops	2¾ x 1½ x ½	Oven-braised at 300° F. to 185° F. internal temp.	25	106	0.11	9
Pork 2, loin and rib chops	2½ x 1½ x ½	Oven-braised at 300° F. to 185° F. internal temp.	33	102	0.16	7
Veal, round steaks	3¼ x 2 x ⅝	Oven-braised at 300° F. to 170° F. internal temp.	37	104	0.10	15
Lamb, rib, loin, and sirloin chops	2¼ x 1 x ½	Oven-braised at 300° F. to 180° F. internal temp.	33	102	0.17	8
Chicken, fryers, thighs	2¼ x 1½ x 1	Oven-braised at 325° F. to 180° F. internal temp.	21	99	0.15	13
Turkey, thighs and legs sliced	3 x 2 x ⅝	Oven-roasted at 325° F. to 185° F. internal temp.	30	100	0.35	11
Salmon, steaks	5½ x 4½ x ⅝	Baked at 400° F., 20 min.	23	97	0.08	18
Tuna, steaks	4½ x 3½ x 1	Baked at 400° F., 30 min.	38 (includes skinning & boning)	102	0.21	17
Shrimp, whole	3 x 1⅜ x ¾	Lowered into boiling water, simmered, 10 min.	25	97	0.14	10
Oysters, whole	2½ x 1 x ½	Lowered into boiling water, simmered, 6 min.	21	99	0.16	17

a combination of cooking and dehydration which would produce a good quality product. In the first method of cooking in hot oil under vacuum, the dehydration time was only 1.5 hours. However, the beef steak had shrunk to half of its original size, was dark brown in color and quite stringy in appearance. The dried meat was palatable and had a meat taste although it was quite tough and dry. Soaking in water at room temperature for an hour gave no appreciable rehydration. Although advocated by some, such products can be ruled out as a substitute for freshly cooked meat but they could be used as an emergency ration substituting for meat bars. In the second method evaluated, half-inch steak was vacuum roasted to an internal temperature of 140° F. in 3 hours with a water loss of 60% whereas the control roasted under the same conditions at atmospheric pressure cooked in 1 hour with a water loss of 35%. Subsequent freeze-drying of both the vacuum roasted product and the control showed that they had equal drying times. In general, after they were rehydrated and evaluated, the organoleptic properties of the vacuum roasted and the control sample were similar and not objectionable. In view of the length of time for vacuum roasting and the need of subsequent freeze-drying, this method appears more expensive than the method finally accepted which consisted of conventional cooking followed by freeze-drying.

Freeze-drying of precooked meats. Drying curves for some precooked freeze-dried meats, poultry, and seafoods together with temperature plots are given in Figure 1 to illustrate the type of data obtained in this study. In Table 1 are given the important variables affecting drying rate and the time for drying to 2% water for the various meats, poultry, and seafoods. The freeze-drying of precooked meat is similar to that of raw meat with low thermal conductivity of about 0.02 BTU/(hr.)(ft.)(°F.) limiting the drying rate. Because of similar physical structure it is probable that the density and porosity of precooked freeze-dried meat is very similar to raw freeze-dried meat and mass transfer of water is not a problem during drying. Thus, for the data presented in Table 1, the

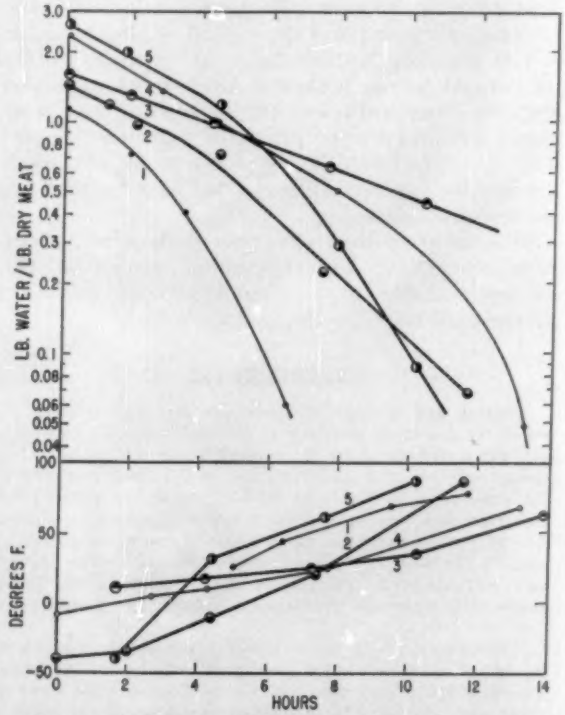

Figure 1. Losses in weight and increases in internal temperature as a function of time during freeze-drying: 1. Pork 2; 2. Salmon; 3. Beef 2; 4. Chicken; 5. Shrimp.

TABLE 2

Properties and storage changes of precooked freeze-dried meats, poultry and seafoods

Food	Rehydration liquid	Rehydration		Decreases in hedonic scores for													
		Atmospheric pressure 15 minutes	Vacuum 2 minutes	Flavor					Color				Tenderness				
				Precooking and freeze-drying	6 months storage, ° F.				Precooking and freeze-drying	6 months storage, ° F.			Precooking and freeze-drying	6 months storage, ° F.			
					40	70	100	130		40	70	100	130		40	70	100	130
	Per liter boiling water	%	%															
Beef 1	4 cubes beef bouillon	64	92	5	4 (4 mo.)	5 (4 mo.)	5 (4 mo.)	...	2	4 (4 mo.)	4 (4 mo.)	5 (4 mo.)	...	5	4 (4 mo.)	4 (4 mo.)	5 (4 mo.)	...
Beef 2	1 cube beef bouillon, 8 g. sodium chloride, .4 g. sodium pyrophosphate	77	...	3	3	...	...	5	2	2	...	...	5	2	3	...	...	5
Beef 3	2½ cubes beef bouillon, 7.5 g. sodium chloride, .75 g. sodium pyrophosphate	78	82	3	4	3	3	3	2	4	3	3	4	3	3	4	4	3
Pork 1	3½ cubes beef bouillon	55	83	3	2 (4 mo.)	4 (4 mo.)	5 (4 mo.)	...	2	2 (4 mo.)	2 (4 mo.)	6 (4 mo.)	...	3	3 (4 mo.)	3 (4 mo.)	4 (4 mo.)	...
Pork 2	1 cube beef bouillon, 8 g. sodium chloride, .4 g. sodium pyrophosphate	41	...	0	2 (4 mo.)	...	...	3	0	2	...	...	4	1	4 (4 mo.)	...	...	5
Veal	¾ cube beef bouillon, 5 g. sodium chloride, .25 g. sodium pyrophosphate	59	74	2	3	2	2	3	1	1	0	1	3	4	5	2	3	5
Lamb	10 g. sodium chloride, .5 g. sodium pyrophosphate	77	94	2	3	3	3	3	0	3	2	2	4	2	4	3	3	5
Chicken	1 cube chicken bouillon, 8 g. sodium chloride, .4 g. sodium pyrophosphate	68	63	0	1	2	2	4 (4 mo.)	1	2	1	1	4 (4 mo.)	1	1	2	3	4 (4 mo.)
Turkey	2½ cubes chicken bouillon, 7.5 g. sodium chloride, .56 g. sodium pyrophosphate	74	79	2	2	4	3	3	2	1	3	3	2	1	1	3	2	4
Salmon	12 g. sodium chloride, .6 g. sodium pyrophosphate	81	78	0	0	0	0	2 (3 mo.)	0	1	1	2	5 (3 mo.)	3	1	0	1	2 (3 mo.)
Tuna	12 g. sodium chloride, .6 g. sodium pyrophosphate	95	112	0	2	1	0	1	0	1	3	2	2	0	3	1	1	3
Shrimp	12 g. sodium chloride, .6 g. sodium pyrophosphate	57	83	1	1	1	3	3	2	1	1	2	2	1	1	1	1	2
Oysters	5 g. sodium chloride, .25 g. sodium pyrophosphate	62	63	2	3 (3 mo.)	1 (2 mo.)	1 (2 mo.)	3 (2 mo.)	0	2 (3 mo.)	0 (2 mo.)	2 (2 mo.)	3 (2 mo.)	0	0 (3 mo.)	0 (2 mo.)	0 (2 mo.)	1 (2 mo.)

small variation in pressures and plate temperatures among the various samples have little effect and the dominant factor limiting the drying rate is the thickness of the pieces. For example, those samples ½ inch thick, except for the oyster, had shorter drying times than the thicker samples. Thus, ½ inch thick pieces of pork, lamb, and shrimp dried in 7 to 10 hours as compared to the thicker samples of beef, poultry, and fish which required 13 to 20 hours. The reasons why ½ inch thick oysters required 17 hours was not determined. As can be predicted from theoretical considerations *(1)* the temperatures during the freeze-drying of precooked meats, poultry, and seafoods remain very low. At the beginning and during the removal of the first one-third of the water, the drying temperature was below 14° F. The temperature remains below freezing until approximately 0.5 lbs. of water/lb. dry weight is reached.

Rehydration. The averages of values for rehydration of individual samples given in Table 2 show that precooked freeze-dried meat, fish, and poultry have relatively poor rehydration characteristics. This lack of complete rehydration is one of the major factors affecting quality of the rehydrated precooked products. As in the case of raw freeze-dried meat, the rate of rehydration is primarily dependent on the rate of flow of water through the capillary openings into the central portion of the meats. Rehydration of large pieces of meat becomes very rapid when the samples are rehydrated in vacuum and this is the preferred method of rehydration.

Water vapor equilibria. A knowledge of the relationship between water vapor pressure and water content of freeze-dried precooked meat is desirable for determining water content of the freeze-dried meats by measuring the vapor pressure, in choosing proper operating conditions for commercial freeze-drying, and in determining the applicability of inpackage desiccation. The relationship between the water vapor pressure and the water content of precooked freeze-dried beef and pork is shown in Figure 2. Two samples of beef and pork showed no essential differences on a dry fat-free basis. In contrast to raw freeze-dried beef which has a low vapor pressure below 2 g. water/100 g. dry fat-free beef, the precooked beef and pork have a relatively high vapor pressure at these low water contents. The relatively high water vapor pressures of 2 mm. at 1 g. water/100 g. dry fat-free beef and pork indicate efficient water removal under the usual operating conditions of commercial freeze-dyers, that is, 0.5 to 1.0 mm. pressure. This relationship also suggests that the use of inpackage desiccation should be highly efficient in lowering the water content to negligible amounts.

Initial hedonic scores and storage stability evaluation. Because of the exploratory nature of this research a broad survey of the organoleptic properties and the storage stability of these precooked freeze-dried meats, poultry, and seafoods was undertaken. The large amount of experimental data does not lend itself to detailed presentation here. The average hedonic score of the ten-member panel was con-

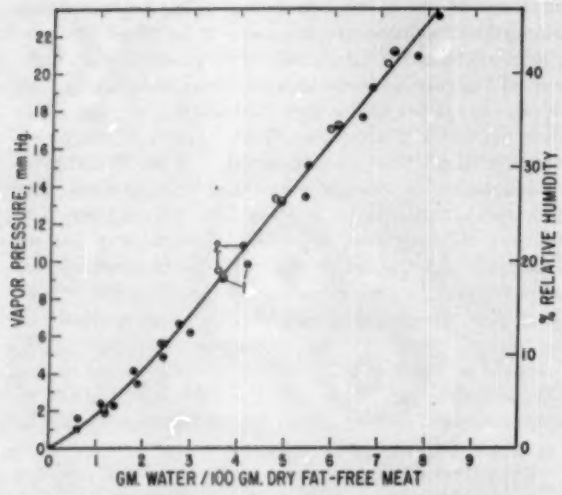

Figure 2. Vapor pressure-water content relationship of precooked freeze-dried beef and pork at 100° F.: 1. duplicate samples of beef 2; 2. duplicate samples of pork 2.

sistently about 7 for the control sample of meats, poultry, and seafoods. Because of the survey nature of this organoleptic evaluation, only relatively large changes are significant for discussion here and these can be expressed as differences between the test sample and the control expressed to one significant figure. Results expressed as decreases in hedonic scores for flavor, color, and tenderness at the initial time and after approximately 6 months' storage at 4 different temperatures are given in Table 2. Because the changes in rehydratability during storage were small, these data are not included.

Precooked, freeze-dried beef 1 had poor flavor and tenderness initially and these did not change significantly on storage. The reason why this beef 1 was so poor immediately after precooking and freeze-drying could only be related to an apparent oxidative fat rancidity. Beef 1 samples exhibited typical rancidity odors and when assayed for peroxide and carbonyls had values characteristic of rancid meats. Since beef 1 was freeze-dried at very low pressures and subsequently packed in pure nitrogen, this oxidative fat rancidity could only be related to deterioration during cooking process and subsequent handling in freezer and room atmospheres containing oxygen.

In beef 2, prepared by essentially the same method except that all visible fat was removed prior to cooking, this difficulty of oxidative fat rancidity was not apparent. Removable of all visible fat is important not only to prevent oxidative changes during high temperature cooking and subsequent processing, but also to prevent a migration of the fat into the dry protein portions of the meat and the resulting adverse effects on rehydration. As in most of the meat, poultry, and seafood samples stored at 130° F. beef 2 underwent pronounced browning during 6 months' storage. The spectral characteristics of the brown color at 3½ months are given in Figure 3. The loss of the spectral characteristics of oxymoglobin which are present in the interior of precooked freeze-dried meat held at 40° F. is apparent. The most interesting characteristic of some of the precooked meats, of which beef 2 is an example, is the development of desirable flavored browning products after storage at 130° F. and 100° F. In beef 2, maximum desirable browning flavor was reached after 2 months at 130° F., at which time the hedonic score was only 1 less than the control. For the next 4 months thereafter, there was a steady decrease of the hedonic score to 5 below the control. This increase in desirable flavor by browning during storage of precooked dehydrated beef and pork has been previously noted by others *(5)* and is a dominant storage characteristic of precooked meat as compared with raw freeze-dried meats. In raw freeze-dried meats, browning is a deteriorative reaction and leads only to decreases in flavor *(1)*.

Pressure-cooked beef 3 had similar initial organoleptic properties to oven-broiled beef 2, but better storage stability. This sample illustrates the extreme storage stability which can be achieved for precooked meat under these packaging conditions. Besides color changes there is little change in tenderness and flavor even after 6 months' storage at 100° F. and 130° F. This study indicates that although the initial organoleptic properties of pressure-cooked and oven-broiled beef need improvement, there is every indication of high storage stability of these products.

Oven-braised pork 1 was similar to beef 1 in having poor initial organoleptic properties and showing poor stability at 100° F. Likewise, this poor flavor was related to oxidative fat rancidity by the rancid odor, peroxide and carbonyl determinations on the fat. When excess fat was trimmed off of the pork before cooking as in pork 2, this problem was eliminated. Pork 2 underwent pronounced browning during 6

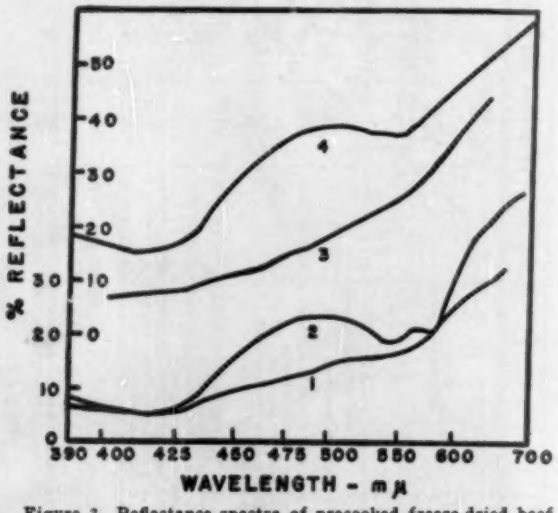

Figure 3. Reflectance spectra of precooked freeze-dried beef and pork: 1. Beef 2, stored 3.5 months at 130° F.; 2. Beef 2, control sample held at 40° F.; 3. Pork 2, stored 3.5 months at 130° F.; 4. Pork 2, control sample held at 40° F.

months' storage at 130° F. and the spectral characteristics of the color at 3½ months are shown in Figure 3. These spectra show the loss of the hemichrome absorbance characteristics of well cooked pork and the formation of a brown color having very little spectral character. At 130° F. this color was apparent after 2 weeks' storage and this browning induced a desirable flavor change at 2 months' storage.

The initial hedonic scores for veal and lamb show the need for improvement in processing to get more natural flavor and to increase tenderness which is mainly a function of rehydration. The small decreases in the hedonic scores for 6 months' storage at 40, 70, 100 and 130° F. show that veal and lamb have excellent storage stability with respect to flavor.

In terms of organoleptic properties, precooked, freeze-dried chicken was one of the best products and compared favorably with pork 2. The chicken sample showed good storage stability during 6 months' storage at 100° F. and below. Turkey was a poorer product than chicken and its storage stability was slightly less. Both chicken and turkey stored at 130° F. showed an increase in hedonic scores at 2 months caused by increased desirable flavor from the browning reaction.

The two fish samples, salmon and tuna, had good organoleptic properties initially and good storage stability. The samples held at 130° F. browned and showed increases in desirable flavor at 2 months and the increasing brown color throughout the 6 months. In the case of tuna the hemichrome pigment masked most of this color formation, whereas in the case of salmon this brown color was undesirable. Shrimp was a good product initially and had excellent storage stability. Only at severe temperature conditions of 130° F. was browning a dominant problem. The initial flavor of oysters needs improvement and the storage stability changes in flavor were pronounced. At 130° F. the browning reaction was a dominant discoloration problem in oysters.

SUMMARY

Precooked freeze-dried beef, pork, veal, lamb, chicken, turkey, salmon, tuna, shrimp and oysters were prepared. The time required for freeze-drying was mainly a function of thickness. Rehydration in 212° F. water at atmospheric pressure was poor. Some of the meats, poultry, and seafoods had good organoleptic properties and most of them were stable for six months' storage at 70° F. and 100° F. Samples stored at 130° F. developed a desirable flavored browning during the first two months and began deteriorating thereafter. The water vapor equilibria of precooked freeze-dried beef and pork is favorable for freeze-drying and use of inpackage desiccation.

Acknowledgments

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Time-Temperature Tolerance of Frozen Foods

IX. Effect of Time and Temperature on Color Distribution in Retail Packs of Frozen Raspberries

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THIS PAPER deals with the objective measurement of color as a means of estimating time-temperature experience in frozen raspberries. Van Arsdel *(5)* and others *(2, 3)* have discussed the extent to which frozen foods are exposed to relatively high temperatures during their commercial lives.

During our work on commercially packed frozen raspberries we observed repeatedly that the sirup of samples stored at 10° to 25° F. was more intensely colored than that of control samples kept at −20° F. This change in sirup color is discussed as a possible indicator of time-temperature experience. Other changes which occur in frozen raspberries are discussed in detail later *(1)*.

EXPERIMENTAL

Analytical methods. To express the observed color changes quantitatively it was necessary to devise a simple accurate procedure for measuring the characteristic red color of frozen raspberries. Absorption spectra of diluted thawed juice and aqueous extracts of thawed berries are shown in Figure 1. Maximum absorption of all color solutions tested occurred at approximately 513 mμ. This indicates no significant alteration of the characteristic raspberry color during extraction from the berries. It also indicates that storage at 30° F. for 2 weeks does not cause any shift in the characteristic absorption spectra of fresh frozen berries but merely causes a certain amount of pigment transfer from berries to sirup. The extent of pigment transfer depends, among other things, on the original pigment concentration in the berries and the time and temperature of storage. As seen from the absorption curves, 2 weeks at 30° F. causes a relatively large transfer of pigment from fruit to sirup. This transfer obviously necessitates different dilutions of the colored solutions in order to permit transmittance readings in the more sensitive range of the photoelectric colorimeter. Although the absorption curves shown in Figure 1 were obtainend with a recording spectrophotometer, absorbancy measurements on all other samples were made with an ordinary photoelectric colorimeter equipped with a filter having maximum transmission at approximately 515 mμ.

To determine the effect of dilution on absorbancy of the solutions, various aliquots of juice were made to 100 ml. with MacIlvaine's citrate-phosphate buffer adjusted to pH 3.0. Data in Figure 2 show that the absorbancy of the final diluted solutions is proportional to the amount of original juice taken. Therefore, the juices can be diluted as required and the photometric density of the diluted juice may be multiplied by the total dilution factor to give an arbitrary number which will be referred to as "color index" of the undiluted juice.

To determine the amount of color that remains in the thawed berries, 100 grams of drained berries were extracted in a blender with 500 ml. of 0.25% oxalic acid. After filtering through Whatman No. 5 filter paper, various amounts of the filtrate were made to 100 ml. with MacIlvaine's buffer, and the absorbancies of the diluted solutions were determined. Figure 3 shows a linear relationship between the amount of filtrate and photometric density over a fairly wide range. As in the case of the juice, this allows a wide choice of dilution, and the color of the berries can be expressed in terms of "color index" by multiplying the photometric density of the diluted filtrate by the total dilution factor. For example, 100 g. of berries extracted and diluted to a total volume of

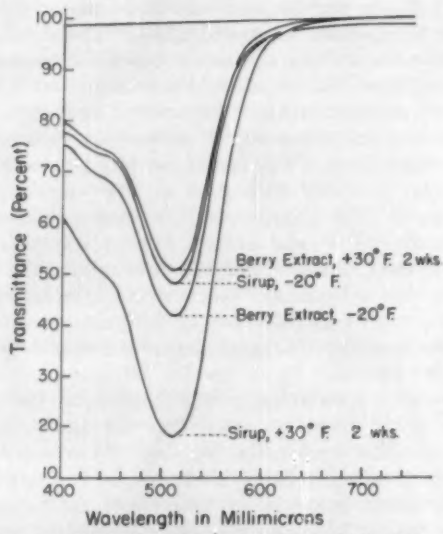

Figure 1. Absorption spectra of color obtained from control and stored samples of frozen raspberries.

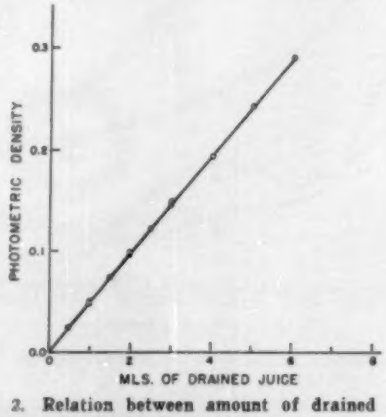

Figure 2. Relation between amount of drained raspberry juice and photometric density at 515 mμ.

* Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

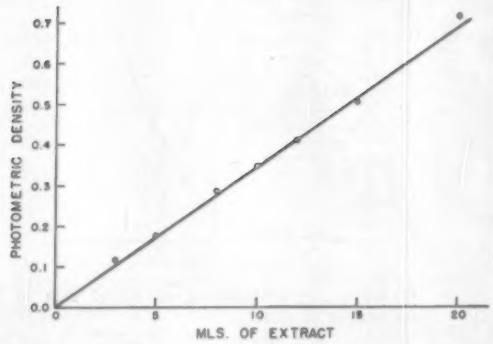

Figure 3. Relation between amount of berry extract and photometric density at 515 mμ.†

† Extracts prepared from 100 g. berries in 500 ml. of 0.25% oxalic acid.

600 ml. gives a 6-fold dilution; then 5 ml. of this solution is further diluted to 100 ml. (20-fold dilution). The photometric density of the latter solution is 0.175; therefore the color index of the berries is 0.175 x 20 x 6 = 21.0.

As seen in Table 1, the berry-to-extractant ratio can be varied over a 2-fold range without affecting the amount of color extracted. This is convenient in that there are no rigid limitations on the amount of berries and extractant required for satisfactory results. This feature in addition to the linearity between photometric density and dilution of juice or berry extracts makes for more ease and flexibility in carrying out the color determinations.

Effect of pH on the absorption of raspberry pigment is similar to that reported by Sondheimer and Kertesz *(4)* for the anthocyanin pigment in strawberries. That is, the absorption is increased by lowering the pH or decreased by raising the pH up to a value of 5–6. Since we are interested in the relative distribution of color rather than the total amount at any given time, all measurements were made at pH 3.0 ± 0.05 and the color index was based on the absorption obtained at this pH alone. There was no particular reason for selecting a pH value of 3.0 except that the natural pH of raspberries is very near this figure.

Since the data in Table 2 show no appreciable change in absorption of pigment solutions adjusted to pH 3.0 and held at room temperature for 1 hour, measurements may be made at any time during this interval.

Detailed procedure for color measurement. All samples for analysis were thawed in the draft of an electric fan at room temperature for 2 hours and then drained on 8-mesh stainless-steel screens for 2 minutes. All the drained berries were then homogenized in less than one minute in a blender and 50 to 100 g. of the homogenized pulp was extracted in 500 ml. of 0.25% oxalic acid solution. The only reason for using oxalic acid in the extractant was to protect ascorbic acid, which was routinely determined on the same filtrate used for color measurement. Pulp was extracted in a blender operated at high speed for 1 to 2 minutes and then filtered through folded filter paper. Two to 5 ml. of filtrate was diluted to 100 ml. with MacIlvain's citrate-phosphate buffer adjusted to pH 3.0, and this solution was again filtered through Whatman No. 5 filter paper. The absorbancy of the clear solutions was then determined in a photoelectric colorimeter.

Color of the drained juice was determined by diluting a suitable aliquot (1 to 5 ml.) to 100 ml. with pH 3.0 buffer, filtering and measuring the absorbancy of the solution in the same instrument with optically matched colorimeter tubes.

TABLE 1

Effect of pulp to extractant ratio on the "color index" of thawed and drained raspberries

Pulp to extractant ratio	Dilution factor	Color index
1:10	110	22
1:6.7	110	22
1:5	120	22

TABLE 2

Effect of delay after dilution and pH adjustment on the photometric density of raspberry extracts[1]

Sample	Photometric density		
	Delay in hours		
	0	0.5	1.0
1	.115	.114	.114
2	.182	.182	.182
3	.286	.285	.284
4	.349	.347	.347
5	.412	.409	.409
6	.512	.509	.509

[1] Extracts prepared by blending 100 g. of berries in 500 mls. of .25 per cent oxalic acid, filtering and diluting with pH 3.0 buffer.

Experimental materials and procedure. Most of the frozen raspberries used were packed and frozen in various commercial plants in the Pacific Northwest. Berries were commercially harvested, processed, packaged in composite (metal end) containers, and frozen in air blast freezers at temperatures of 0° to −40° F. Most of the samples were obtained in 12-oz. containers packed with approximately 9 oz. of berries and 3 oz. of 50% sucrose sirup. A total of 16 different "lots" of berries was used, each consisting of 120 to 960 packages. Each lot was selected to represent as many differences as possible with respect to commercial growing, processing, packaging, freezing, etc.

In addition, 4 additional lots were prepared in the Fruit and Vegetable Products Laboratory of this Division at Puyallup, Washington. These were packed in enamel-lined No. 2 cans and represented differences with respect to maturity, fruit-to-sirup ratio, and delay between packing and freezing. Berries were carefully sorted into normally mature and overmature, including broken berries. Normal berries were divided into 3 lots and treated as follows: one lot was packed with one part of 50% sucrose sirup to 2 parts of berries; the second lot, like all others, was packed in a 3-plus-1 ratio and the third lot was delayed 6 hours prior to freezing. The fourth lot consisted of overmature and broken berries.

Cans were frozen in a −10° F. air blast and after freezing was completed, all samples including the commercial packs were shipped to Albany, Calif., in containers packed with dry ice. All the frozen berries were then stored at −20° F. until the storage experiments at higher temperatures were begun.

Representative samples from all the different lots were then stored at temperatures of 0°, 10°, 15°, 20°, and 25° F. After various storage periods at these temperatures, at least 4 packages from each lot were removed and immediately cooled to −20° F. This temperature was used to maintain the condition of the samples as they were at the time of removal from the higher storage temperatures. Samples were then thawed and analyzed with regard to color distribution and other factors.

RESULTS AND DISCUSSION

Effect of storage temperature on sirup color. The curves in Figure 4 show the pronounced effect of temperature on the color of the drained sirup. At 0° F. only a very slight increase in the color of the sirup had occurred after one year of storage. At 10° F., however, there was a marked increase in sirup color. After only 3 months at this temperature the increase in sirup color was approximately 4 times greater than that which occurred at 0° F. in one year. As

the temperature was increased further, relatively greater increases in sirup color occurred until a maximum value was reached.

At temperatures of 15° F. and below, the berries are to a large degree in a solidly frozen condition, and therefore the amount of pigment transferred from berries to sirup is necessarily small in comparison to the total amount present in the berries. Even though the berries are hard frozen, a certain amount of liquid, containing soluble color and other constituents, remains unfrozen and is presumably drawn into the sirup by diffusion. As the temperature is increased to 20° F. and above, the berries become progressively softer and contain increasing amounts of unfrozen liquid which is transferred to the sirup at a much more rapid rate.

The degree of solid-to-liquid change is obviously critical in the range of 15 to 25° F. This is indicated by the fact that a temperature difference of 5° F. in the 15–25° F. range causes several times as much sirup color change as occurs in the 0–15° F. range for the same temperature difference. This is illustrated in Figure 5 where the initial rate of color transfer is plotted againsnt temperature. In the same way, the storage time necessary to cause an equivalent change in sirup color varies markedly with the temperature. For example, an increase of 3 "color index" units requires approximately 2, 6, 28, and 70 days at 25, 20, 15, and 10° F., respectively. While sirup color is markedly influenced by temperature during storage periods of 1–2 months or less, eventually a maximum color value is approached which is more or less independent of the temperature. However, the time required to reach the maximum value or any other value is always a function of storage temperature.

Effect of raw material on sirup color and color ratio. Up to this point we have considered the sirup color changes occurring as a result of time-temperature experience in one fairly uniform lot of frozen raspberries. Obviously different lots of berries may have different amounts of color and therefore the maximum sirup color value and the rate of approach to this value will depend on the original berry color. Figure 6 shows large variations in sirup color on 16 different "lots" of commercially frozen raspberries. The variations were just as great or greater after storage at 20° F. as they were in the −20° F. controls.

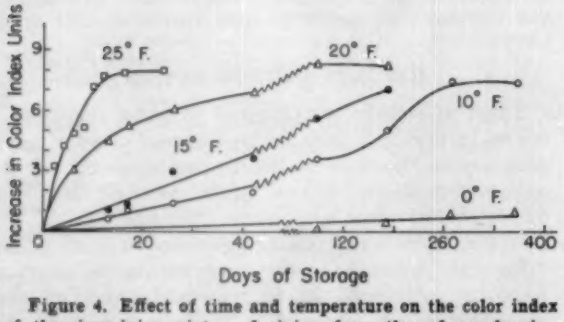

Figure 4. Effect of time and temperature on the color index of the sirup-juice mixture draining from thawed raspberries.

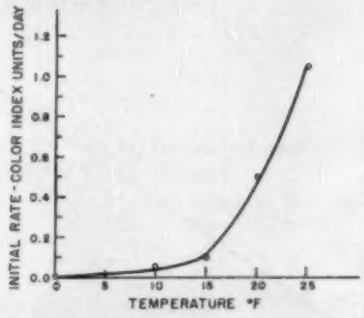

Figure 5. Effect of temperature on initial rate of color transfer from berries to sirup.

Sirup color values of samples stored for various periods at +20° F. overlapped so badly that it was impossible to make a reasonably good segregation as to storage history on the basis of the sirup color alone. The data in Table 3 indicate little or no loss in color when the determination is made on the entire package contents without segregation of berries and sirup. It appears that storage at 20° F. for as long as 77 days causes no substantial oxidation or deterioration of the pigment responsible for the red color of raspberries. Therefore, total color measurements without segregation of berries and sirup are of little or no value in estimating temperature history in frozen raspberries. Since the total amount of color remains fairly constant, the color changes during storage are changes in distribution or changes in the ratio of the "color index" of the fruit to the "color index" of the sirup. In other words, as the color intensity of the sirup increases, the amount of color in the berries decreases until the "color index" of berries and sirup is approximately equal. If the color ratio is defined as the "color index" of the drained berries divided by the "color index" of the sirup which is drained from those berries, it is clear that the color ratio will decrease with increasing time and temperature. Samples that have not been exposed to high temperatures should have relatively high color ratios because the color in the berries has not had an opportunity to diffuse into the sirup. The ratio in these samples will vary considerably depending on the original color of

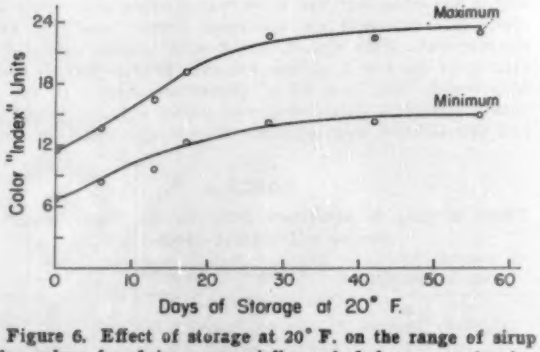

Figure 6. Effect of storage at 20° F. on the range of sirup color values found in commercially packed frozen raspberries.

TABLE 3

Effect of storage at 20°F. on the color index of berries and sirup combined

Sample	Color index					
	Storage time in days					
	2	5	17	42	56	77
1	16.5	17.5	16.5	15.7	16.3	16.0
2	11	10.5	10.5	10.2	9.8	9.9
3	17.4	16.7	18.0	16.5	16.3	16.9
4	16.2	16.7	17.2	16.0	15.5	16.1
5	16.6	17.4	16.8	16.2	15.9	15.9

the berries, their condition, etc. When the samples are stored at relatively high temperatures, however, the amount of color which bleeds into the sirup for any given time and temperature will depend to a large extent on the original amount of color in the berries themselves; and therefore the color ratio should be practically independent of original berry color under the same storage conditions. The color data obtained on drained berries and sirup after various storage periods at 20° F. was calculated and plotted as color ratio versus time. The relationship is shown in Figure 7 and represents values obtained from 16 different commercial "lots." It will be noted that the substantial variation in color ratio for the "zero time" samples is markedly reduced after 10–20 days' storage at 20° F. Comparing the curves in Figures 6 and 7 it is readily apparent that expression of the color changes occurring in the berries and sirup as a ratio greatly reduces the variations observed in sirup color alone. Using color ratios it was possible to distinguish between various temperature histories irrespective of the original color of these commercial samples.

Effect of processing variables on color ratio. The effect of delay, fruit to sirup ratio, and overmature and broken berries is shown in Figure 8. As was found in the commercial samples, these controlled processing variables caused considerable variation in the color ratio of the various samples prior to storage at elevated temperatures. The lowest ratio was obtained for overmature and broken berries principally because free juice exuding from broken overripe berries immediately colored the sirup to an extent depending on the degree of breakage and color intensity of the berries. The highest ratio was found in the normal berries packed in a 2 + 1 ratio. This result may be explained on the basis of approximately equal

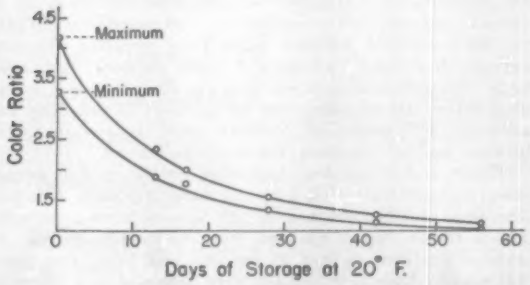

Figure 7. Effect of storage at 20° F. on the range of color ratio values found in commercially packed frozen raspberries.

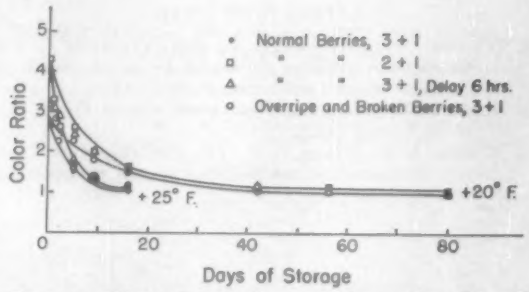

Figure 8. Effect of processing variables on the color ratio of frozen raspberries stored at 20 and 25° F.

amounts of juice and coloring matter exuding into the sirup of samples receiving the same freezing and thawing treatment. Since the 2 + 1 pack has a larger volume of sirup per unit of berries, and the amount of color diffusing into the sirup during thawing is approximately the same, it is clear that color intensity of sirup in the 2 + 1 pack will be lower, thus giving a higher color ratio. Delaying the samples six hours prior to freezing did not appear to cause any appreciable differences in color ratio prior to storage at 20 and 25° F. Although the variation due to treatment amounted to approximately 1.5 color ratio units prior to storage, it was reduced to 0.3 − 0.4 of a unit after 5 days and to approximately 0.2 of a unit after 17 days at either 20 or 25° F. These samples may be segregated on the basis of storage time for periods up to approximately one month at 20° F. and 17 days at 25° F. irrespective of the processing treatments which were employed. After these storage periods, the color ratio remains fairly constant at a value of approximately 1.0, and therefore no further segregation with respect to time and temperature may be made on a color basis alone.

SUMMARY

A procedure for the determination of color in frozen raspberries is described. Data presented show that sirup color increases markedly with storage time for temperatures of 10° F. and above, but changes only slightly at 0° F. or lower. For uniform lots of berries sirup color serves as a useful index of the accumulated time-temperature experience of a given sample. In samples differing with respect to original berry color, wholeness, and fruit-to-sirup ratio, determination of the sirup color alone is not sufficient for a reasonable estimation of time-temperature experience. In these instances color determinations on both sirup and drained berries are necessary. During storage at 20–25° F. expression of fruit and sirup color as a ratio tends to eliminate variations due to original color and processing conditions, and thus permits evaluation of temperature history irrespective of these variables.

Acknowledgment

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Effects of Packaging on Partially Baked Rolls:

Observations on the Retention of Riboflavin, Moisture, and Flavor

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Considerable interest has recently been focused on the retention of riboflavin in enriched bakery products. Interest in this subject was greatly stimulated by the work of Loy, Haggerty and Combs *(3)*. They studied the effects of light on the riboflavin, thiamine and niacin content of enriched partially baked rolls and white bread. Their findings revealed that exposure of cellophane-wrapped rolls to artificial light resulted in significant losses of riboflavin after two days. Although it was observed that losses of riboflavin were greatly increased if the rolls were not wrapped, no direct comparisons of different packaging materials were made. Several studies were conducted by other workers concerned with the effects of packaging materials on the retention of riboflavin in enriched white bread *(4)*.

The two studies reported here were designed to test the relative effects of aluminum foil, waxed paper and cellophane wraps on the retention of riboflavin, moisture and flavor in partially baked rolls.

EXPERIMENTAL METHODS

The partially baked rolls were obtained through the cooperation of a local commercial baking company. Sixty random samples were selected from a normal production batch of approximately 600 ten-ounce packages. The sample rolls were removed from the middle portion of the batch from the delivery end of a continuous oven. Dough from which the rolls had been formed was fortified with vitamin enrichment tablets.

The 60 experimental packages were wrapped immediately after they had been partially baked and cooled. Twenty packages each were wrapped in heat-sealing aluminum foil-wax-paper-wax, unprinted 300 MST 51 cellophane and partially printed 40 No./ream waxed paper. (The waxed paper was that currently in use by the baking company for bread wrapping. The majority of the surface was opaque white with a small amount of red and yellow printing). All packages were machine wrapped and heat sealed, with special care taken to insure formation of complete seals.

After rapid transportation to the laboratory, 2 packages of each of the 3 wraps were assayed for riboflavin and moisture content. Average values for these 6 assays were designated as the initial moisture and riboflavin contents of the rolls. Twelve packages wrapped in each of the 3 experimental materials were immediately subjected to surface light of 100 foot candle intensity. The majority of the light was supplied by four 40-watt fluorescent tubes spaced evenly 4 feet above a 3 x 8 foot table on which the packages were placed. A small part of the incident light was provided by a north window exposure near the storage table. Fluorescent lighting was regulated to illuminate only during the hours 8:00 A.M. to 6:00 P.M. These lighting conditions were designed to simulate those in a rather brightly illuminated food market *(4)*. Storage temperature of the room was between 74–78° F. Eighteen packages of the foil-wrapped rolls were held in frozen storage to provide control samples for flavor evaluation.

Samples wrapped in each experimental material were assayed for riboflavin and moisture content after 1, 2, 3, 5, 7 and 14 days' exposure. Riboflavin assays were performed according to the U.S.P. microbiological method with *Lactobacillus casei* the test organism *(5)*. Moisture analyses were performed by the A.O.A.C. vacuum oven procedure *(1)*. Samples were prepared for riboflavin and moisture analysis by grinding one 8-roll package in a hand food grinder under subdued light conditions. The ground sample was then placed in an amber colored glass screw cap container and refrigerated in the dark until analysis. All samples of partially baked rolls were assayed in duplicate for riboflavin and mositure content.

Flavor evaluations were performed on the various wrapped samples at intervals of 3, 7 and 14 days' exposure. One package each of rolls wrapped in the 3 experimental materials, plus a frozen control package, were browned uniformly in a large rotary oven at 350° F. for one half hour. One-quarter roll samples from each package were presented to a 15-member trained panel in multiple comparison. Rolls were served warm.

The panel was composed of individuals who had demon-

strated ability to detect small changes in the flavor of rolls of the type under study. About 35 persons who had had experience in evaluating flavor differences in other products were screened for participation in the panel for partially baked rolls by having them judge 3 triangular tests of fresh rolls and rolls which had been subjected to 98° F. temperature for 24 hours. Seventeen of the 35 candidates were able to identify correctly the like pair of samples in two or three of the triangular tests presented. Fifteen of these judges were used for the evaluation of the partially baked rolls under study. Ages and sex of the judges were randomly distributed.

Four coded test samples were presented simultaneously to the judges. Random arrangement of the samples was followed. Each sample was scored according to a 5-point scale. An example of the score card used is shown in Figure 1. Numerical scores of +2, +1, 0, −1 and −2 were assigned to the descriptive terms for analytical purposes. Scores on duplicate samples were obtained from each judge. Averages of the duplicate scores were analyzed according to the method of Kramer and Ditman *(2)*.

Experimental methods described above were applied to two separate studies. The first study, conducted in August, 1956, was deemed to be quite conclusive but to obtain confirmation of the results, a repeat study was performed in February, 1957.

RESULTS AND DISCUSSION

Moisture analyses were performed to enable calculation of riboflavin contents on a uniform dry weight basis and also to measure relative values of the various packages in protecting against moisture losses. In Table 1 are presented data on percentages of moisture in partially baked rolls after storage in the 3 wrapping materials. No marked differences were detected among the packages in either degree or rate of moisture loss, at least during the first 7 days' storage. It was quite evident, however, that changes in texture developed during the test. After 7 days' exposure, waxed paper wrapped rolls were slightly less soft and pliable to the touch. After 14 days' storage both waxed paper and cellophane wrapped rolls were harder than foil wrapped rolls. This effect was less noticeable in the 1957 study when the initial moisture content of the rolls was about 1% higher. Hardening effects shown in the 1956 study may have been due to the transfer of moisture from starch to gluten within the roll structure.

Results of the riboflavin assays are presented in Table 2. Substantial reductions in riboflavin content were detected in cellophane and waxed paper wrapped rolls but not in rolls wrapped in aluminum foil. Relative rates of loss of riboflavin at the various storage intervals are shown in Figure 2. It should be mentioned that results of the microbiological assay procedure are subject to normal variation of approximately ± 10%. Curves indicate that greatest losses of the vitamin occurred during the first 3 days of exposure to light. These results compare well with those of Loy *et al. (3)* although lighting conditions were somewhat different. It is readily apparent that waxed paper wrap reduced and foil wrap essentially eliminated losses of riboflavin. Increased amounts of riboflavin in all samples after 14 days' storage may have been due to a synthesis of small amounts of riboflavin by molds which had then developed to a slight extent in all 3 wraps.

Tables 3 and 4 present the results of flavor evaluations performed on the browned rolls. The panel consistently gave the highest scores to the frozen control and foil wrapped samples at each storage interval tested. Next highest scores were received by rolls wrapped in waxed paper. Lowest scores were consistently given to the rolls wrapped in cellophane. Both total and average scores listed in Tables 3 and 4, respectively, reflect the magnitude of differences

Product_____

Date_____ Taster_____

Sample Marking				
(+2)[1] Entirely Acceptable Flavor				
(+1) Probably acceptable Flavor				
(0) Questionable Flavor				
(−1) Probably off-Flavor				
(−2) Definitely off-Flavor				

[1] Numerical scores assigned to the descriptions.

Figure 1. Score card employed for evaluating flavor differences in partially baked rolls.

TABLE 1

Percent moisture in partially-baked rolls after storage in various wrapped materials[1]

Days storage	1956			1957		
	Cellophane	Waxed paper	Aluminum foil	Cellophane	Waxed paper	Aluminum foil
0	31.1	31.1	31.1	32.4	32.4	32.4
1	30.3	30.5	30.1	31.9	32.0	32.2
2	30.3	30.4	30.7	31.7	31.5	31.9
3	29.7	29.4	30.7	31.7	31.5	31.9
5	29.5	29.7	29.9	31.1	30.8	31.2
7	30.4	30.3	30.0	31.1	30.0	31.2
14	28.0	28.7	30.4	30.1	28.8	30.7

[1] Figures represent averages of duplicate analyses on sample from one eight-roll package.

TABLE 2

Riboflavin[1] in partially-baked rolls after storage in various wrapping materials. (Milligrams riboflavin/100 grams)[2]

Days storage	1956			1957		
	Cellophane	Waxed paper	Aluminum foil	Cellophane	Waxed paper	Aluminum foil
0	0.29	0.29	0.29	0.33	0.33	0.33
1	0.22	0.25	0.29	0.24	0.29	0.30
2	0.19	0.24	0.28	0.18	0.25	0.28
3	0.18	0.20	0.28	0.16	0.23	0.28
5	0.17	0.20	0.28	0.14	0.20	0.29
7	0.12	0.17	0.28	0.12	0.20	0.32
14	0.16	0.21	0.31	0.13	0.21	0.35

[1] Calculated on a dry weight basis.
[2] Figures represent averages of duplicate analyses on sample from one eight-roll package.

TABLE 3

Total flavor scores, ranges and least significant differences required for significance among total flavor scores

Days Storage	1956						1957					
	3		7		14		3		7		14	
	Total	Range	Total	Range	Total	Range	Total	Range	Total	Range	Total	Range
Frozen control	18.0	2.0	18.0	2.5	24.5	1.0	17.0	3.0	18.0	2.0	24.0	2.5
Cellophane	9.5	4.0	−5.5	3.5	−10.5	4.0	9.0	3.5	3.5	4.0	−2.0	4.0
Waxed paper	10.5	3.0	10.5	3.0	7.5	3.0	13.5	3.0	10.5	4.0	12.0	3.0
Aluminum foil	14.5	2.5	17.5	2.5	25.0	1.0	17.0	3.0	18.0	2.0	17.0	3.0
L. S. D. .05	8.7		8.7		6.75		9.38		9.0		9.38	

TABLE 4

Average flavor scores and least significant differences required for significance among average scores

Frozen control	+1.20	+1.20	+1.63	+1.13	+1.20	+1.60
Cellophane	+0.63	−0.37	−0.70	+0.60	+0.23	−0.13
Waxed paper	+0.70	+0.70	+0.50	+0.90	+0.70	+0.80
Aluminum foil	+0.97	+1.17	+1.67	+1.13	+1.20	+1.13
L. S. D. .05	0.58	0.58	0.45	0.625	0.60	0.625

between samples as determined by the panel. Relationship between these scores and average consumer acceptance was not determined.

SUMMARY AND CONCLUSIONS

Two studies were conducted to compare the relative effects of three wrapping materials on the retention of riboflavin, moisture and flavor in partially baked rolls. The results of storage of the rolls under 100-foot candles of light revealed significant losses in riboflavin during the first seven days of storage when packaged in typical commercial cellophane and waxed paper. Such losses were not observed in rolls packaged in aluminum foil. Slight losses in moisture were quite comparable among the three test packages. There occurred definite, undesirable changes in flavor in the rolls after seven days storage when packaged in cellophane. Foil-wrapped rolls showed better retention of their original flavor and texture than did rolls wrapped in waxed paper and cellophane.

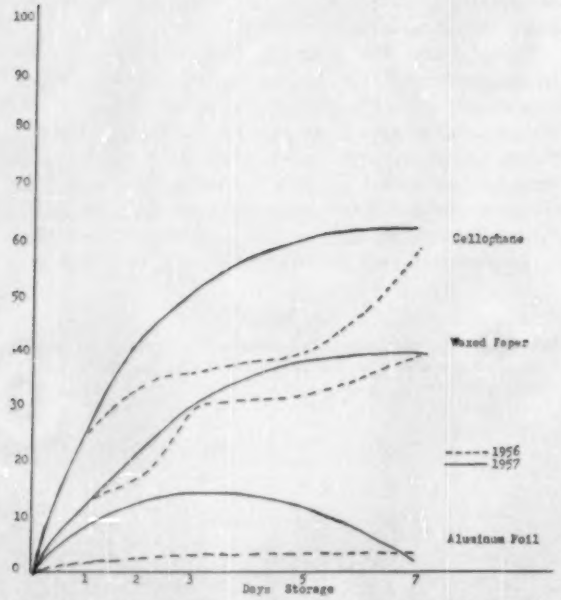

Figure 2. Per cent loss of riboflavin (on dry weight basis) in partially baked rolls in various packaging materials.

Acknowledgment

The studies were sponsored by the Reynolds Metals Company, Louisville, Kentucky. The cooperation of the Gardner Baking Company of Madison, Wisconsin, in obtaining and wrapping of the partially baked rolls is greatly appreciated.

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Tenderness and Juiciness of Veal Loin Roasts and Chops

A Comparison of Methods of Measuring Those Qualities[a, b]

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(Manuscript received June 19, 1957)

WITH THE CHARACTERISTIC LACK of fat and higher percentage of connective tissue in veal, the cooked meat is sometimes dry and stringy. Steam, as in braising, or liquid, as in a stew, has been useful in producing more palatable products. Yet, there is interest in the initial quality of veal as related to juiciness and tenderness and in any practical production factors which might be used in an effort to improve its quality.

Methods of measuring a food attribute may be tested by comparison of some physical test with the reaction of a sensitive, trained panel of judges to learn whether the test actually measures the same characteristic of the food and how modification of procedures would increase precision. Thus, in this report, three conditions were used for the determination of press juice and compared with judges' scores as measures of juiciness. Also, two subjective evaluations of tenderness were made on the same chops as were used for a modified Warner-Bratzler test and a grinding test for measurement of tenderness.

EXPERIMENTAL METHODS

Veal loin roasts were removed for cooking tests, wrapped with glassine laminated locker paper, and held in frozen storage at −8° F. until tested. In Series 1 loin cuts were prepared as roasts and in Series 2 as braised chops. Samples for these tests were obtained from male, 6-weeks old calves of Holstein or Brown Swiss breed. At 4 days of age, calves were placed in one of 3 groups for different feeding methods, and were slaughtered at 6 weeks of age. Group 1 calves were fed all of the Holstein whole milk they would eat at 2 daily feedings, with no other feed or liquid. Group 1b differed from Group 1a in the addition of iron and copper solutions to the milk fed. Group 2 calves were placed on a limited whole milk, calf-starter and hay feeding plan. Group 3 calves were fed a milk replacer (all they would drink without digestive upset), a calf-starter, and hay *ad lib*. All calves received a 30 mg. capsule of aureomycin daily. Details of the feeding and handling procedures, as well as additional data on results of the various feeding methods, are given by Niedermeier *(2, 3)*.

Cooking procedure. For Series 1, short loin cuts were thawed, wrapped, at refrigerator temperatures for 3 days. They were roasted in a preheated electric oven at 300° F. to an internal temperature of 175° F. Temperatures were determined by the use of copper constantan thermocouples and a potentiometer. Total weight loss during thawing and cooking, as well as the dripping and evaporation losses, were computed. Each testing period compared one roast from each of the 4 feeding methods.

For Series 2, loin chops were braised. Roasts were cut into 1½ inch chops while still frozen, rewrapped, and put back into the freezer until needed. They were thawed at refrigerator temperatures as needed for the testing. Four chops from each short loin were browned at 475° F. for 2 minutes on each side, using one-half tablespoon of fat in an iron skillet. Browned chops were placed on a rack in a pan and 50 ml. of water added and the pan covered with aluminum foil. A thermocouple was placed in one of the 4 chops and the wire bent under the foil to give a tight seal, holding in the steam. They were cooked in an oven at 250° F. to an internal temperature of 180° F. Cooking losses were computed as loss in weight of the chops.

Subjective tests. The *longissimus dorsi* muscle was cut from the cooked roast of Series 1 and a portion sliced into one-half inch slices starting at the rib end of the roast. The second through the fourth slices were used for the judging panel. Outside fat and connective tissue bands were removed. Cubes of warm meat from the same location in comparable slices from the 4 roasts were given to the same judge at any one judging period. From replicate to replicate, however, the sliced portions were not the same for the same judge. Scoring was based on a one-to-ten scale for juiciness. No subjective assessment of tenderness was made. Coding and the order in which the judges tasted the meat were assigned in random order. Samples were warm and served on warm plates. Judges were graduate students or faculty members from the Animal Husbandry or Foods and Nutrition Departments. They were given a short training period. The judging room was quiet, uniformly lighted, and judges did not face one another.

For the chops of Series 2, the *longissimus dorsi* was used for rating by a judging panel for the characteristic of tenderness in two different ways. Uniformly-sized samples were presented to the judges in a random order. The first measure was to ask the judges to check a list of words describing tenderness: *very tender, tender, moderately tender,* or *slightly tough, tough,* or *very tough*. These descriptive words were later assigned a value of one to five respectively, thus indicating that a rating of a low number showed greater tenderness. This was therefore the judgment of their initial impression as they began to chew the meat. The second measure was to count the number of "chews" which were required to masticate the

[a] Publication approved by the Director of the Wisconsin Agricultural Experiment Station.

[b] Supported in part by F. B. Morrison Fund.

same piece of meat until they were willing to swallow it. These were, of course, very subjective measures in both cases.

Objective tests. For Series 1, a measurement of tenderness was made in terms of shearing force. One-inch cores were cut from the cold *longissimus dorsi* parallel to its length. Triplicate tests were made on the Warner-Bratzler Shearing apparatus, being careful to eliminate areas of fat.

Two objective measures of tenderness were used for the meat from the chops in Series 2. It was difficult to get a sufficient length for the cores from the chops to give a cutting on the Warner-Bratzler Shearing apparatus. Recourse was had to a procedure of pulling apart the fibers of the *longissimus dorsi* and arranging them parallel to each other. Bundles of ⅝ inch diameter were then tied tightly and were cut on the Warner-Bratzler Shearing apparatus. The second method for tenderness is one suggested by Miyada and Tappel *(1)* and consisted of measuring the force required to grind ½ inch cubes of meat in a grinding attachment to an electric mixer. Samples of 100 g. of the meat were used. Curves relating amperage to time of grinding were drawn and the area in square inches under the curve was measured with a polar planimeter from zero time to 60 seconds. Both of these objective tests for tenderness were made on the cold meat the day following its cooking.

In Series 1, 3 techniques were used for press juice, all of which were determined on a Carver Press at 450 pounds p.s.i. for 1½ minutes. For one procedure, half-inch cubes of meat (3 g. or slightly less) were cut from the roasts within an hour after they were taken from the oven and tested warm. The other two tests were made on cold meat the following day, one on 3-g. cubes and in Method 3 on 15 g. of meat ground through the plate of a food chopper having 1/16 inch openings. For all of these three techniques, weights were taken to show the loss in weight from the meat under pressure and the gain in weight of the wrapping cloth or of the pad. In Series 2, only one technique for press juice was used—that of the 5 gram sample of cold ground meat described for Method 3.

RESULTS AND DISCUSSION

Data of Series 1 on the veal loin roasts are summarized in Table 1. It can be noted that the weight of the roasts from the calves was much higher for liberal whole milk feeding than for limited whole milk or milk-replacer feeding. Losses during cooking, however, showed little variation in total loss or in dripping or evaporation loss. Comparative methods for assessing the juiciness of the meat were the subjective judging and various procedures for obtaining press juice. The judges indicated no marked difference in their scores, the average being 7.1 to 7.6 on the basis of 10 as the most desirable juiciness. From the press juice, which was determined on a Carver press by three different methods, the only striking difference was in the higher percentage of liquid from samples which were tested warm. An average of about 10% more juice can be expressed from the meat tested within one hour after being taken from the oven than in the cold meat tested the following day. On the cold meat, the two methods differed in the size and shape of the samples. In Method 2, a cube of 3 g. in weight was pressed, whereas in Method 3, 15 g. of ground meat was put into the Carver press. There was little difference between groups in the percentage of juice expressed from the cold meat by either method. Thus, whether one considers the cooking losses or the judges' scores or any one of the procedures for press juice, no marked difference between feeding methods was shown.

Only one test of tenderness of the veal roasts was carried out, the force required to cut a one-inch core taken from the *longissimus dorsi*. These cores may have varied to some extent in the way the grain of the meat was cut as well as in the amount of fat or connective tissue present. The average shear values in Table 1, as well as the analysis of variance in Table 2, showed a significant difference in tenderness in the various feeding methods. When the averages are compared with the least significant difference at the 1% level, it was found that feeding method 1b was significantly different from Methods 2 and 3; Methods 1a and 1b differed significantly at the 5% level.

For the tests of Series 2, several changes were made in the procedure. Since veal loin is usually served in the home as a braised chop, that cookery method was chosen and the procedure well standardized. More emphasis was placed upon the methods of assessing tenderness in this series of tests. Data are summarized in Table 3 with analysis of variance for many of the characteristics presented in Tables 4 and 5.

Weight of the 4 chops from feeding method 1b was the greatest and was significantly different from treatments 2 and 3, but not from feeding method 1a. There was no significant difference in cooking loss. The press juice which was determined only on 15 g. cold ground meat was analyzed in terms of the liquid

TABLE 1

Average values for the tests made on veal loin roasts

Feeding method	1a Liberal whole milk	1b Liberal whole milk plus iron and copper	2 Limited whole milk	3 Milk replacer
Weight of roast (raw)	1387 g.	1541 g.	1163 g.	1077 g.
Total cooking loss in per cent of raw roast weight	19.4	19.2	19.0	21.3
Dripping loss (%)	2.4	2.8	1.1	1.2
Evaporation loss (%)	17.0	16.4	17.9	20.2
Juiciness score	7.1	7.6	7.4	7.5
Press juice (% of weight)				
Method 1 — Warm	41.2	41.7	41.4	43.6
Method 2 — Cold	32.3	33.1	33.7	34.3
Method 3 — Cold	32.8	33.1	35.0	32.9
Shear value (pounds)	9.4	5.4	10.7	13.0

TABLE 2

Analysis of variance of shear values of meat from veal loin roasts

Source of variation	Degrees of freedom	Sums of squares	Mean square	F
Among feeding methods	3	934.00	311.33	6.118[2]
Among triplicates	2	14.36	7.18	
Error	107	5,190.78	50.89	
Total[1]	112	6,139.14		

L.S.D. for feeding methods at 5% level, 3.536; at 1% level, 4.678.

[1] Includes 7 missing values estimated in analyses.
[2] Significant at the 1% level.

TABLE 3

Average values for tests made on braised veal loin chops

Feeding method	1a Liberal whole milk	1b Liberal whole milk plus iron and copper	2 Limited whole milk	3 Milk replacer
Weight of 4 chops	1037 g.	1138 g.	860 g.	846 g.
Total cooking loss (%)	22.0	25.0	24.0	24.4
Press juice (% of weight)				
a. From sample	28.2	27.6	31.2	32.2
b. Absorbed by pad	25.7	25.6	28.1	27.4
Shear values (pounds)	28.3	21.8	32.9	25.8
Grinding test (area in sq. in.)	6.3	5.7	6.1	6.3
Judges' ratings	2.7	2.3	3.0	2.6
Number of "chews"	37.2	33.8	38.9	36.3

pressed from the sample and also the amount of liquid absorbed by the pad. It is to be noted that there was always a lesser amount absorbed by the pad than was expressed from the sample, this amount varying from 7.2 to 14.9% of the loss. One may well surmise that liquid was lost by evaporation and some lost by coating the cylinder used in the determination. It is to be observed, however, that feeding methods 1a and 1b were significantly lower in press juice than feeding methods 2 and 3. This is true whether the loss in weight of the sample or amount absorbed by the pad is considered. There was very little suggestion of that difference in press juice from the data of Series 1.

Four methods were used for assessing the tenderness of the veal chops. For the Warner-Bratzler shear tests, the fibers were torn apart and packed very tightly in parallel fashion giving a very compact sample to be cut. In the statistical analysis, Table 5, feeding method 1b was shown to produce significantly more tender veal, as measured by shear values, than feeding method 2. Methods 1a and 3 ranged between these two and were not significantly different from either of the extremes. The differences in shear values between Methods 1a and 1b were significant at the 5% level, the liberal milk feeding with iron and copper additions being superior. The method of using the area of the curve representing the grinding force in an electric mixer attachment did not produce a significant difference between the various feeding methods. The conditions of our test were different from those of Miyada and Tappel who proposed this method in a recent paper *(1)*. The degree of sensitivity was not great enough to indicate statistical significance, but it can be observed that Method 1b did give the smaller area which would be related to greater tenderness. The judges' ratings of the meat being tender or tough were assigned numerical values and subjected to an analysis of variance. Again the lower rating indicating greater tenderness was found in the calves fed by Method 1b. These were found to be significantly different from all other methods, but no other comparison was significantly different. From the number of "chews" there was again found a significant difference at 5% level, feeding method 1b being more tender than feeding method 2. Methods 1a and 3 ranged between these 2 values.

The trend in all 5 objective tests of tenderness (the one of Series 1 and four from Series 2) indicated that feeding method 1b produced more tender veal. Although the judges differed significantly in the number of "chews" required and in their ratings of tenderness, they too indicated that the more tender veal came from feeding method 1b with the less tender produced by feeding method 2. One can also deduce from the statistical analysis that the variations between samples within feeding methods was quite large. On the other hand, the variations between duplicates of the samples are in every case minor.

One further comment or comparison needs to be discussed. It was obesrved early in the study that the veal from feeding method 1b had bones of a brighter red color and that the meat also tended to hold its redness during cooking. Internal temperatures chosen for both the roasts and the chops were increased a bit after our preliminary trials in order that the meat in treatment 1b would not carry too much red color. In order to assure sensitivity in tenderness

TABLE 4

Analyses of variance of the weights of chops, cooking losses and press juice

Determination made	Source of variation	Degrees of freedom	Sum of squares	Mean squares	F
Weight of 4 chops	Among feeding methods	3	600231.40	200077.13	7.643**
	Within feeding methods	36	942450.20	26179.17	
	Total	39	1542681.60		
Cooking loss	Among feeding methods	3	51.37	17.09	0.743 n.s.
	Within feeding methods	36	828.29	23.01	
	Total	39	879.56		
Press juice	Among feeding methods	3	351.92	117.31	14.07**
	Samples vs. pads	1	378.23	378.23	45.35**
	Between duplicates	1	17.03	17.03	2.04
	Error	148	1234.10	8.34	
	Total	153	1981.28		

L.S.D. at 1% level for influence of feeding methods on weight of chops = 196.8; at 5%, 146.7
L.S.D. at 1% level for influence of feeding methods on press ju[illegible] = 1.686; at 5%, 1.277.

TABLE 5

Analyses of variance for data from four methods of assessing tenderness

Determination made	Source of variation	Degrees of freedom	Sum of squares	Mean squares	F
Shear values	Among feeding methods	3	1335.29	445.097	4.809**
	Between duplicates	1	8.00	8.000	0.086
	Within feeding methods	74	6849.42	92.560	
	Total	78	8192.71		
Grinding test (area in sq. in. under curve)	Among feeding methods	3	2.9200	0.9733	0.768 n.s.
	Within feeding methods	32	40.5668	1.2677	
	Total	35	43.4868		
Judges' rating of tenderness	Among feeding methods	3	27.20	9.067	6.570**
	Among judges	7	24.40	3.486	2.526*
	Interaction of methods x judges	21	17.64	0.840	0.609
	Error	216	298.13	1.380	
	Total (8 missing values estimated)	247	367.37		
Number of "chews"	Among feeding methods	3	1615.35	538.45	2.63*
	Among judges	7	33648.90	4806.99	32.40**
	Interaction of methods x judges	21	873.25	41.58	0.28
	Error	215	31898.12	148.36	
	Total (9 missing values estimated)	246	68035.62		

L.S.D. at 1% level for feeding methods on shear values = 8.04; at 5% level, 6.063.
L.S.D. at 1% level for feeding methods on tenderness ratings = 0.54; at 5% level, 0.41.
L.S.D. at 5% level for influence of feeding methods on number of "chews" = 5.60.

and juiciness tests, the veal was not as thoroughly cooked as a housewife would desire. It is believed that the intensity of the red color would not be a problem or a disadvantage when the meat was cooked under practical conditions and to the usual standard. Detailed color determinations on raw meat were made and are reported by Niedermeier *(2, 3)*.

CONCLUSIONS

Press juice determinations may be made on either warm or cold cubes of lean meat or on ground cold meat. There was little difference in methods except for the greater amount of expressible liquid from the warm samples and the lesser amount absorbed by the pad than was lost in weight from the meat.

Under the conditions of test in this laboratory, the measurement of force to grind meat from braised veal chops showed no significant difference between feeding methods.

Shear force values and two methods of evaluation of tenderness by a judging panel gave statistically significant differences of the same trend between various methods of feeding calves. Variation between judges was marked, particularly when the number of "chews" was the criterion used.

The feeding of calves on whole milk with iron and copper addition produced more tender veal than the three other feeding methods. The more intense red color of the bones is believed not a disadvantage when veal is thoroughly cooked by braising.

Acknowledgments

Thanks are expressed to Mrs. Frieda Cohn for the statistical analyses and to Paul Cleary, Robert Hendrickson, Radley Hyde, Shirley Kremer, Vera McCoy, and Janet P. Robinson for technical assistance in this work.

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The Symposium on the Maturation and Germination of Peas

Frank A. Lee

New York State Experiment Station, Geneva, New York

THIS IMPORTANT SYMPOSIUM was sponsored jointly by the Low Temperature Research Station of the University of Cambridge (L.T.R.S.), England, and the Fruit and Vegetable Canning and Quick Freezing Research Association, Chipping Campden (F.V.R.A.). It was held at L.T.R.S. on June 20 and 21, 1957.

The June 20th Sessions

The Symposium was divided into two parts. The first, which covered the practical aspects of the subject, was held on June 20.

Morning Session

The morning session was opened by Dr. E. C. Bate-Smith, Superintendent of the Low Temperature Research Station. It was then turned over to Mr. F. Hirst, as chairman. Mr. Hirst was the Director of the Fruit and Vegetable Canning and Quick Freezing Research Association at Chipping Campden before he retired recently.

Following this introduction, the present Director of the Fruit and Vegetable Canning and Quick Freezing Research Association, Mr. W. B. Adam, gave a talk on the subject: The ripening of green peas in relation to canning and freezing. R. W. Graham and G. Evans (Unilever Ltd.) followed with a paper on the standardization and operation of Tenderometers.

Afternoon Session

The chairman was Dr. J. Philip, Director, National Vegetable Research Association. Speakers and the titles of papers presented at this session were:

Prof. F. A. Lee (Cornell University). The evaluation of the maturity of peas.

R. S. Mitchell, Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.), Australia, and L. J. Lynch (C.S.I.R.O.). Some aspects of the maturity of green peas and measures for its prediction. (This paper was introduced by Dr. A. B. Hope (C.S.I.R.O.) in the absence of both of the authors.)

P. H. Lefebvre, Institut National pour l'amélioration des Conserves de Légumes (Inaco), Belgium. Maturation of round seeded peas.

Dr. D. Dickinson (F.V.R.A.). Some problems of the dried pea canning industry.

Dr. A. Schneider, Institut für Pflanzenzüchtung Quedlinburg, Germany. The rate of maturation of peas in relation to variety and meteorological factors.

The June 21 Sessions

The second part of the Symposium was devoted to the fundamental aspects of the subject, and was held on June 21.

Morning Session

Professor T. A. Bennet-Clark, F.R.S. (King's College, London) served as chairman. The papers presented follow:

Dr. H. G. Wager (L.T.R.S.). The physiology of maturing peas.

Dr. S. P. Spragg (National Vegetable Research Association). Protein synthesis in the maturing pea seed.

H. D. Fowler, M.Sc. (University College, Cardiff). Mattson's theory of texture of peas in relation to changes in phytin and orthophosphate during maturation.

Dr. D. B. Robertson (C.S.I.R.O., Australia) and Dr. J. F. Turner (C.S.I.R.O., Australia). Changes in developing pea seeds. Introduced by Dr. A. B. Hope (C.S.I.R.O.), in the absence of both authors.

Dr. R. G. Tomkins (Ditton Laboratory) and Dr. H. G. Wager (L.T.R.S.). Refrigerated gas storage of peas.

Afternoon Session

Dr. E. C. Bate-Smith (Superintendent, L.T.R.S.) served as chairman.

Dr. L. W. Mapson (L.T.R.S.). The development of certain respiratory enzymes in germinating peas.

Dr. D. J. Manners (University of Edinburgh) and Dr. F. A. Isherwood (L. T. R. S.). Starch structure and pea quality.

Prof. F. A. Lee (Cornell University). The lipids of peas and their part in the deterioration of flavor and color.

Discussions of the papers were held.

Seventy-seven people registered for the Symposium, and some others arrived after the Symposium started. Participants and speakers were from the following countries: Australia, Belgium, British Isles, Denmark, Germany, India, Italy, Netherlands, and the U. S. A.

Research Associations, Universities and Technical Colleges, Government Laboratories, Foreign Trade Organizations, Industries, and Industrial Laboratories were represented. This Symposium underscored the importance of and interest in the pea as a processed item in Europe as well as in this country.

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First Call for Nominations for Babcock-Hart Award

In accordance with the rules and regulations governing the Babcock-Hart Award, Nutrition Foundation, Inc., donor, nominations are solicited from members of the Institute. Nominations should be in the form of a two page, single spaced, typewritten letter giving a biographical sketch and qualifications of the individual recommended for the Award. Such letters should be sent to G. F. Garnatz, Chairman, Babcock-Hart Award Jury, The Kroger Food Foundation, 1212 State Avenue, Cincinnati 4, Ohio. They must be received by January 1st, 1958. If you have someone in mind who, in your opinion, is eligible for this Award, do not delay; send in your nomination to the Chairman of the Jury now!

Masters and Doctors in Food Technology and Related Subjects—1957

Additional advanced degree winners have been supplied by Pennsylvania State University officials. The list includes Master's degrees taken in January, June, and August of 1957. Doctoral degrees awarded by Pennsylvania State University were reported previously.

Pennsylvania State University, University Park

Name	*Degree*	*Title of Thesis*
Allison, William H.	M.S.	An Investigation of Antibiotics as a Control of Bacterial Blotch on the Cultivated Mushroom
Csenge, John I.	M.S.	The Use of Tetrazolium for Determining Keeping Quality of Milk and Other Dairy Products
Estep, Roger D.	M.S.	Effects of Population Density and Equipment Arrangement on Broiler Production and Market Quality
Henson, William L.	M.S.	The Effect of Population Density on Egg Quality
Hepler, Roger W.	M.S.	The Development of a Screening Program for Bacterial Wilt Resistance in Sweet Corn
Timm, Herman	M.S.	The Influence of the Chloride Ion upon Potatoes
Voight, Alvi O.	M.S.	Characteristics of Milk Production and the Alignment of Dairy Farms with Market Outlets in Selected Areas of Central and Southeastern Pennsylvania

IFT News

MINNESOTA

Because the Minnesota Section of the Institute of Food Technologists is newly chartered it has a backlog of meeting reports.

The first meeting of the chartered Minnesota Section was held on May 8, 1957. Institute president (1956–57) George Garnatz, presented Charter No. 28 to the Minnesota Section of The Institute of Food Technologists.

Dr. Garnatz, in his speech, "The Effect of New Foods On Our Living", analyzed the impact of modern "prepared" foods on life in these United States. Thirty years ago a homemaker required 5½ hours to prepare the daily meals for a family of four persons. Today the daily meals for a family of four can be prepared in 1 hour and 36 minutes.

Dr. Emil Mrak
IFT President, 1957-58

Our second meeting under the new charter warmly welcomed Dr. Emil Mrak, newly elected president of The Institute of Food Technologists (1957–58) as guest speaker. His subject, "Wine Technology", dealt with comparisons of American and European wine-making techniques, with particular emphasis on California wines.

The officers of the Minnesota Section for the first year are as follows:

Chairman—George Youland, Green Giant Company.
Chairman elect—Jolyon A. Stein, Pillsbury Mills.
Secretary-Treasurer—Norman Foster, Food and Drug Administration.
Organizational Counselor—Henry Hoffman, Chief Chemist, State of Minnesota.
Executive Committee Member-at-large—John Wintermantel, General Mills.
Executive Committee Member-at-large — James Winter, Dept. of Horticulture, Univ. of Minnesota.

The program schedule for the remainder of the 1957–58 season is as follows:

November 18—"Man—Food and Chemicals", Dr. K. G. Weckel, Dairy and Food Industries Department, University of Wisconsin.
January 20—"The Life of a Wife", Mary Hart, Home Economist, Minneapolis *Tribune*.
March 21—"Canned Foods—Yesterday, Today and Tomorrow", Dr. L. E. Clifcorn, Supervisor of

every old crow thinks her babe is Bee-u-tiful

"Mother-Love" sometimes, and quite naturally, rationalizes the poor sales behavior of a food product where flavor and eye appeal may be out-of-step with changes in consumer preferences.

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Container Utilization, American Can Company.
May 18 (tentative)—"Essential Oils", Dr. E. Gunther, Vice-president, Fritsche Brothers, Inc.

—Franklin L. Sorensen, Jr.

PHILADELPHIA

The October meeting featured Dr. Georg Borgstrom, Professor of Food Technology, Michigan State University, East Lansing, and formerly head of The Swedish Institute for Food Preservation Research. His topic was "Riddles in Frozen Food Microbiology". Dr. Borgstrom, international authority in this field, authored the outstanding review in *Advances in Food Research* entitled "Microbiological Problems of Frozen Food Products." Dr. Borgstrom's talk was most instructive.

Our officers have arranged the following program for the next six meetings. Emphasis will be on the technical aspects of food technology.

November 5, 1957—"Programming a Research Problem", Dr. Sidney Cantor, Consulting Chemist.
December 3, 1957 (Ladies' Night)—"All About Coffee", Dr. F. Greenbaum, Quik-Café.
February 4, 1958—"Freeze-Drying of Foods", Dr. Earl Flosdorf, F. J. Stokes Corp.
March 5, 1958—Joint Meeting with Franklin Institute. Topic and speaker to be announced.
April 1, 1958 (Students' Night)—To be announced.
May 6, 1958—Tour of Atlas Powder Co. Laboratories. "Recent Laboratory and Clinical Research with Lysine", Dr. N. W. Flodin, E. I. duPont Co.

OFFICERS FOR 1957–58:

Chairman—John Crimmins, Lummis & Co.
V. Chairman—Norman Kramer, U. S. Food & Drug Admin.
Secretary—Fred Jacobson, Consultant, 4721 Chestnut Street.
Treasurer—Fred Heitman, Consultant, Plymouth Meeting.
Councillor—Richard Foster, Campbell Soup Co.
Executive Committee—Two years: Robert Lawhorn, Abbotts Dairies; Carl Pratt, Atlas Powder Co. One year: G. D. Boyd, Campbell Soup Co.; A. D. Bowers, Campbell Soup Co.

DIXIE

The summer meeting of the Dixie Section of the Institute of Food Technologists was held on the Alabama Polytechnic Institute Campus, Auburn, Alabama, August 16, 1957. The group assembled in the main lobby of the Auburn Union Building, where lunch was served in the War Eagle Cafeteria. The meeting was called to order by Mr. Charles Lovvorn, vice-chairman. Dr. E. V. Smith, dean of the Agricultural School and Director of the Experiment Station, welcomed the group to the Auburn Campus.

Included on a tour of the A. P. I. Campus was a trip through the new War Eagle Cafeteria kitchen led by Mrs. Inez Tucker, the dietician. Dr. C. A. Basore took the group on a tour of the Chemical Engineering Laboratory and showed processes and equipment adaptable to large-scale manufacture of certain food products. Mrs. Kathryn S. Rush showed us the Food Service Department warehouse and administrative building. All food used on the A. P. I. Campus is bought on a competitive bid basis and issued to each dining hall or cafeteria as needed. Professors L. M. Ware, Hubert Harris, and M. J. Danner toured the group through the processing lab of the Horticulture Department and discussed research in processing and utilization of horticultural crops at Auburn. (This included their sweet potato purée process and their new freezing process in the making of blackberry jams and jellies.) Dr. R. Y. Cannon took us through the College Creamery and Dairy Manufacture Lab and treated the group to samples of their orange drink.

A trip to the Educational Television Station at A. P. I. led by Mr. Tom M. Eden, the director, ended the program.

—Cordelia Ellis

S. CALIFORNIA

The September 18th meeting of SCIFTS was devoted to honoring Mr. Paul S. Armstrong as THE FOOD MAN OF THE YEAR. Recently retired from Sunkist Growers with whom he had been associated for 41 years, Mr. Armstrong was selected for the 1957 award because of his many contributions to his profession and his community. He is first recognized for his leadership in disseminating knowledge concerning the richness and stability of ascorbic acid in citrus products and he is credited with the opening of European markets to American lemon export.

He has sponsored many scientific research studies and through Mr. Armstrong's efforts, Sunkist Growers became one of the first food distributors to make grants to universities for research on foods. Sunkist has continued to support research on citrus fruit and was a founder member of the Nutrition Foundation, of which Mr. Armstrong is a trustee.

Mr. Armstrong's civic activities have included offices on hospital and university boards, Chamber of Commerce and many others. In 1946 he was awarded an honorary degree of Doctor of Agriculture by his alma mater, Michigan State University, and in 1955 a distinguished service award citation.

Mr. Armstrong gave the dinner address, ably reviewing the changes going on in the foods field. The title of his talk was "This Age of Convenience". He attributed the development of convenience foods to three conditions, namely, 1) high cost of labor and shortage in domestic servants, 2) efficiency of agriculture thereby releasing workers for other occupations, and 3) the desire for more leisure by the homemaker.

—Cora Miller

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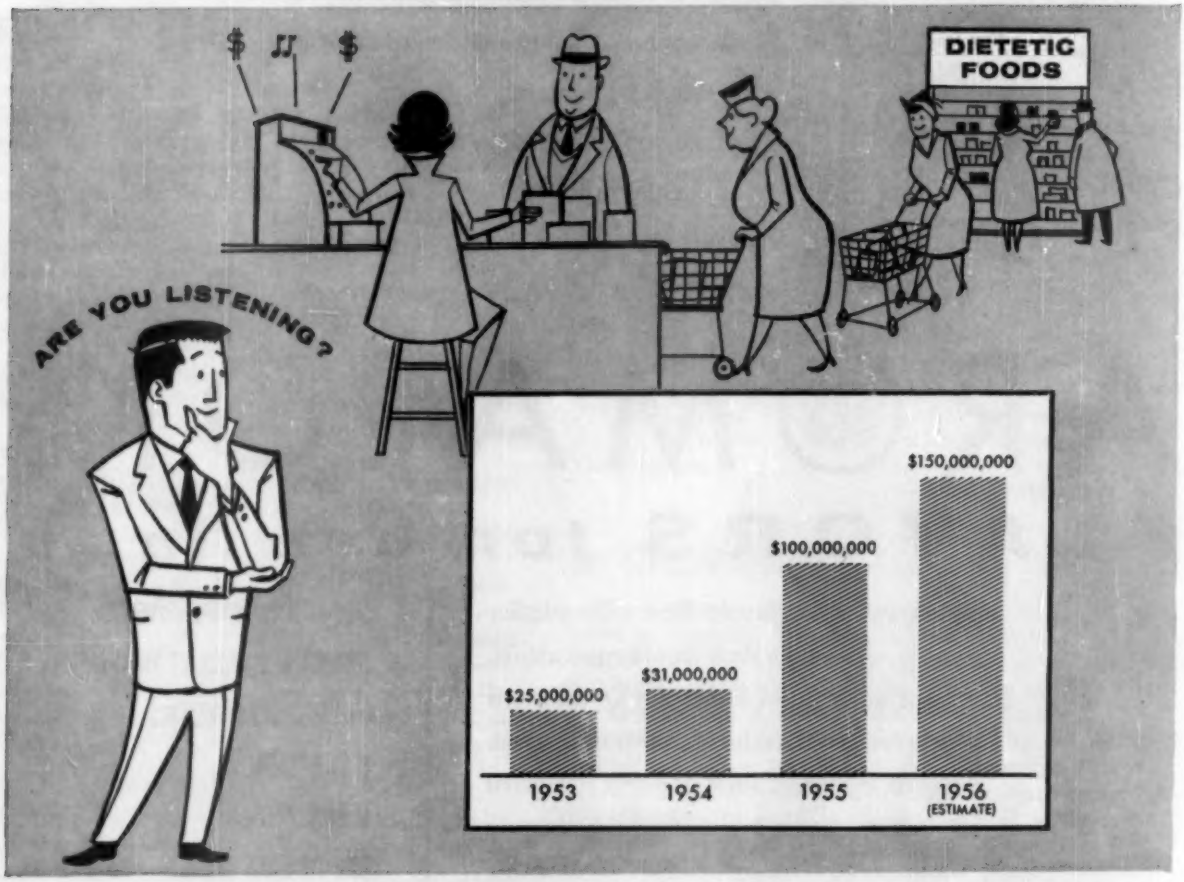

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Literature

BOOKS

FUNDAMENTALS OF CHROMATOGRAPHY. Harold Gomes Cassidy. Interscience Publishers, Inc., New York, 1957, 447 pp.

This is Volume X of the series "Techniques of Organic Chemistry" edited by Arnold Weissberger.

The author has divided his subject into three broad categories and has organized his material in such a manner as to give the reader maximum aid in understanding and utilizing chromatographic techniques:

1. The first four chapters cover the important definitions and describe the nature of chromatography, the molecular interactions upon which chromatographic separations are based, and the general theory of the different processes (adsorption, frontal analysis, etc.) used in chromatography.

2. This information is used to explain the principles of the particular methods of chromatography which are presented in the following seven chapters. Gas-liquid, column, and paper partition chromatography methods are given in separate chapters. These are followed by discussions on adsorption, chromatography, ion exchange, electron exchange polymers and foam and emulsion fractionation. The same general plan is followed in their presentation: the principle of the method is stated; apparatus and materials are discussed; actual manipulations are described; and where possible, factors that influence the separation of materials are discussed.

3. The final four chapters treat types of methods of recognizing and evaluating zones, relations sought and found between R and R_F values and molecular structure in chromatographic separations, choosing mobile and stationary phases, and finally the approach to follow when using chromatography.

There is a short appendix in which the author has gathered together, for the convenience of the reader, lists of sources of chromatography equipment.

A number of graphic illustrations of apparatus and their use are presented throughout the book which proved of considerable aid in understanding the discussion. Sample calculations for individual methods are also frequently presented.

This book should prove helpful to the users of chromatographic methods. It will give them a better understanding of the theory and principles upon which these techniques are based and enable them to utilize more fully present methods and to help in the development of new methods.

ROBERT B. KOCH
Broadview, Illinois

PURE FOOD AND DRUGS IN CALIFORNIA. A. F. Glaive. The National Press, Palo Alto, California, 1957, 204 pp.

In this book Dr. Glaive traces the development of the pure food and drug laws of the state of California, beginning with the first to be enacted in 1850. The opening chapters lay the background of practices and regulations of ancient and medieval times, and the early reports of investigators in several states which culminated in the National Food and Drug Act in 1906.

The history of the Food and Drug Laboratory from its early beginnings, the establishment of the State Board of Health in 1870, which was charged with legal enforcement, and the founding of the present Laboratory with its corps of personnel in 1907 are also recorded. The author pays tribute to Professor M. E. Jaffa, who preceded him for many years as chief of the Laboratory.

Interspersed throughout the text are the reminiscences and experiences of the author, many of which are of authoritative, historical value. The modern reader is prone to forget that the brazen adulterations of foods and of drugs, the deceptions and the filthy practices of an earlier era may be encountered in a more subtle and insidious form today. Deliberate preying upon the gullible, the weak and the despairing with questionable beauty aids, harmful nostrums and today, rocks with radioactive emanations, become subjects for inquiry by the State Food and Drug Laboratory, as well as the more innocent actions which endanger health, such as the ageing of wine in a cask once containing arsenical insecticide. These instances serve to make the text interesting, and at times fascinating, reading.

J. ORVIN MUNDT
Knoxville, Tennessee

ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY, Vol. XV. Ed. by Raymond E. Kirk and Donald F. Othmer. Interscience Publishers, Inc. New York, New York.

The final volume of this notable series was published in December, 1956, and hence it can hardly be regarded as a new appearance. However, Volume XV is mainly index and so a notice, even a belated one, will be useful as a reminder that the key to the wealth contained in the 13,805 text pages of the complete encyclopedia is herein contained. The first volume of the series was published in 1947. Over 1000 authors contributed—60% of them from industry. Dr. R. E. Kirk and Dr. F. Othmer of the Polytechnic Institute of Brooklyn have been the editors-in-chief from the start of the undertaking. Materials, methods, processing, and equipment are comprehensively embraced in the thousands of entries that make up the fifteen volumes. That chemistry and chemical engineering have fostered the development of many phases of food technology is abundantly evident in the encyclopedia. The article on *yeasts* in Volume XV is a case in point and there are innumerable other instances.

M. S. P.

ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

Analysis of corn oil for total tocopherols.

HIVON, K. J. AND QUACKENBUSH, F. W. (Purdue Univ., Lafayette, Indiana). *J. Am. Oil Chemists' Soc. 34*, 310–14 (1957).

A method has been developed to overcome difficulties in the analysis of corn oil for tocopherol. Alkali treatment of the oil and subsequent adsorption on diatomaceous earth reduced the content of interfering constituents to permit analyses for total tocopherol by the Emmerie-Engel method.

An automatically recording vacuum balance.

POPE, M. I. (Washington Singer Labs., The University, Exeter). *J. Sci. Instr. 34*, 229–32 (1957).

The app. described can record changes in wt. of a solid, either in the presence of a gas or *in vacuo*, at temps. of up to 1000° C. to an accuracy of ±0.2 mg. with a total range of approx. 5 g. Simplicity in construction is achieved by use of only standard radio and electrical components. Applications include thermogravimetric analysis, gas sorption and studies of gas-solid reactions.

Zone electrophoresis on sponge rubber.

MITCHELL, H. K. AND HERZENBERG, L. A. (Kerckhoff Labs. of Biology, California Inst. of Technol., Pasadena, Calif.). *Anal. Chem. 29*, 1229 (1957).

Foam rubber is a highly satisfactory supporting medium for preparative sepn. of small amts. of proteins and other electrolytes by zone electrophoresis. Apparatus, its prepn. and operation, is described.

BIOLOGICAL SCIENCE

Biochemistry

Bromelin is now available as commercial enzyme.

ANON. *Food Eng. 29* (5), 186 (1957).

Bromelin, a highly potent protein digesting enzyme extd. from the pineapple plant is now available from Takamine Lab., Clifton, N. J. Typical applications include use in meat tenderizers, chill proofing compds. for beer, protein hydrolysates, and baked goods.

Fructose phosphorylation and dephosphorylation by the intestinal mucosa of the rat during fructose absorption.

PAPADOPOULOS, N. M. AND ROE, J. H. (Sch. of Med., George Washington Univ., Washington, D. C.) *Am. J. Physiol. 189*, 301–6 (1957).

The large increase in fructose phosphate esters in rat intestinal mucosa, observed after fructose administration, suggests that phosphorylation of sugars in absorption serves a more extensive function than to initiate glycolysis for the normal metabolism of the mucosal cells. The data obtained suggest that phosphorylation and dephosphorylation are functional steps in the absorption of fructose from the alimentary tract of the rat.

A crystalline trypsin inhibitor from swine colostrum.

LASKOWSKI, M., KASSELL, B. AND HAGERTY, G. (Marquette Univ. Sch. of Med., Milwaukee, Wis.). *Biochim. et Biophys. Acta 24*, 300–5 (1957).

Swine colostrum contains a trypsin inhibitor in much higher concn. than that previously reported in human or bovine colostrum. The concn. was highest (1 ml. inhibited 2 mg. of trypsin) on the first day after birth and fell gradually almost to zero by the fifth day. Like the majority of naturally occurring trypsin inhibitors of animal origin, the swine colostrum inhibitor is a small protein. Both the free inhibitor and the inhibitor-trypsin complex were obtained in cryst. form; the method of purification is described.

Bifidus factor. Isolation of ethyl N-acetyl-β-D-glucosaminide from Aspergillus fermentations.

POPE, S., TOMARELLI, R. M. AND GYORGY, P. (Wyeth Labs., Inc., West Chester, Pa.). *Arch. Biochem. and Biophys. 68*, 362–6 (1957).

Fermentation by *Aspergillus terreus* in a simple medium contg. degraded chitin increased the microbiol. activity of the culture fluid for the growth of *L. bifidus* var. *pennsylvanicus*. The active principle was isolated and identified as ethyl *N*-acetyl-β-D-glucosaminide.

The essential nature of lysine in the prevention of feather depigmentation of turkey poults.

VOHRA, P. AND KRATZER, F. H. (Univ. of California, Davis). *Arch. Biochem. and Biophys. 68*, 76–80 (1957).

L-Proline, L-ornithine, DL-homocitrulline, DL-pipecolic acid, DL-α-amino hexanoic acid, and ε-aminocaproic acid were inactive in promoting growth or preventing feather depigmentation of turkey poults deficient in lysine. This indicates that the requirement for lysine is specific. ε-N-Acetyl-DL-lysine was utilized approx. 30% as efficiently as DL-lysine in promoting growth of poults. Feather pigmentation was improved somewhat by a high level of the compd.

Microbiology

Enhancement of pathogenicity of enterobacteriaceae for mice by wetting agents.

CHRISTOVAO, D. A. (Univ. of São Paulo). *Proc. Soc. Exptl. Biol. Med. 94*, 724–5 (1957).

Two wetting agents, Decceresol-OT and Duponol W. A., when added to suspensions of *Sh. dysenteriae*, *Sh. paradysenteriae*, *Salm. typhosa*, or *Sh. ambigua*, consistently enhanced the pathogenicity of the organisms for mice inoculated intraperitoneally.

Studies on the mechanism of sorbed water killing of bacteria.

MONK, G. W., MCCAFFRE, P. A., AND DAVIS, M. S. (Chemical Corps., Fort Detrick, Frederick, Md.). *J. Bacteriol. 73*, 661–5 (1957).

The energy and entropy of activation for the killing of *Serratia marcescens* by sorbed H_2O compares more closely to the values for endogenous respiration and growth than to those for thermal killing. At the most lethal H_2O content of about 33%, the existence of measurable endogenous respiration indicates that at least part of the metabolic system is operative in the presence of only small amts. of H_2O. A simple explanation is offered which assumes that a hygroscopic substance which is toxic under these conditions is all in soln. at 33% H_2O. In drier cells less of this substance is in soln., and in wetter cells it is dild. and the cells can resume a more normal metabolic balance.

Agar medium to define acid producing bacteria.

SHANK, J. L., AND SILLIKER, J. H. (Swift & Co. Research Labs., Chicago, Ill.). *J. Bacteriol. 73*, 625–6 (1957).

A new agar medium to detect acid production by "flat sour" organisms is described. The difficulty of interpreting diffuse color reaction when ordinary indicators (such as bromcresol purple) are used is overcome by the addn. of colloidal $CaCO_3$ to the agar. In conjunction with neutral red, acid production is characterized by a clear zone around a red colony.

Nutrition

A diet restricted in refined cereals and saturated fats: Its effect on the serum-lipid level of atherosclerotic patients.

HANDEL, E. AND NEUMANN, H. (St. Antoniushove Hospital, Voorburg, Holland). *Lancet* 245–6, February 2, 1957.

A diet restricting animal fats and degerminated flour, and with supplements of soy lecithin, soybean oil and flour, peanuts, and peas or beans, was successful in lowering the serum-lipids in atherosclerotic patients where they had previously been high.

Utilization of calories from alcohol and wines and their effects on cholesterol metabolism.

MORGAN, A. F., BRINNER, L., PLAA, C. B. AND STONE, M. M. (Univ. of Cali-

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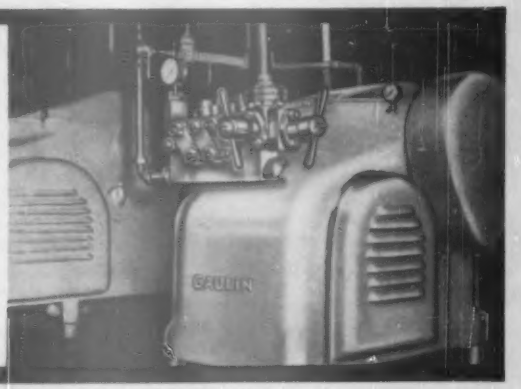

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World's largest manufacturers of homogenizers, colloid mills and triplex high pressure pumps.

fornia, Berkeley). *Am. J. Physiol. 189*, 290–6 (1957).

The utilization of cal. for growth by young rats given an adequate diet, free access to drinking H_2O and supplements of 15 or 20% alc. solns. or wines of the same alc. concn. was equal to that of rats receiving no alc. if the alc. cal. were calcd. as 75% physiologically available. When 1% cholesterol was added to the diet all the rats grew better than on the basal diet and water restriction had less unfavorable effects. Both liver and adrenal cholesterol were much increased by the exogenous cholesterol in all groups but least in the wine fed animals. Restriction of H_2O intake by rats given alc. solns. appears to account for most of the effects of chronic alc. ingestion reported.

The effects of different food fats on serum cholesterol concentration in man.

ANDERSON, J. T., KEYS, A. AND GRANDE, F. (Univ. of Minnesota, Minneapolis). *J. Nutrition 62*, 421–44 (1957).

The serum cholesterol responses to the various fats corresponded roughly to the principle that satd. fats promote higher cholesterol levels than polyunsatd. fats but neither degree of satn. (iodine value) nor content of linoleic acid fully explained the results. Coconut oil is less cholesterol-promoting than would be predicted from the theories that degree of satn. or the content of essential fatty acids is the controlling factor. Sardine oil is considerably less cholesterol-depressing than would be expected if degree of unsatn. is the major factor. Corn oil caused greater depression of serum cholesterol than would be expected from either the essential fatty acid or the degree of unsatn. theories.

Organ weights in three forms of experimental obesity in the mouse.

MARSHALL, N. B., ANDRUS, S. B. AND MAYER, J. (Harvard Sch. Public Health, Boston, Mass.). *Am. J. Physiol. 189*, 343–6 (1957).

Obesity in mice is accompanied by changes in organ weight. Certain changes like the enlargement of the liver, heart and kidneys appear to be nonspecific effects of prolonged hyperphagia. Other changes may be part of a syndrome of which obesity is also a component. The findings emphasize the need for a wider recognition of the differences between obesities of various etiologies and pathogeneses.

Vitamin B_{12} deficiency in the aged.

TAUBER, S. A., GOODHART, R. S., HSU, J. M., BLUMBERG, N., KASSAB, J., AND CHOW, B. F. (Dept. of Research, Home for the Jewish Aged, Phila., Pa.). *Geriatrics 12*, 368–74 (1957).

Aged healthy subjects have low B_{12} serum levels and glutathione content in erythrocytes. Stimulation of the gastrointestinal tract with histamine results in better absorption of B_{12} by young, but not by old subjects. The absorption of this vitamin can be enhanced by noninhibitory intrinsic factors, but not by inhibitory factors. The latter may even deplete B_{12} reserve of test subjects or animals.

Effect of food preferences on nutrient intake.

YOUNG, C. M., AND LAFORTUNE, T. D. (Sch. of Nutrition, Cornell Univ., Ithaca, N. Y.). *J. Am. Dietet. Assoc. 33*, 98–103 (1957).

Food dislikes seem to have little influence on the adequacy of the diet because most intensely disliked food are commonly "seldom served" food items. The greatest effect on adequacy of nutrient intake seemed to lie in lack of ingestion in sufficient quantities of the "choice" food items, such as milk, bread and cereal, and eggs.

Goitrogenic substances in food.

GREER, M. A. (Univ. of Oregon Med. Sch., Portland, Maine). *Am. J. Clin. Nutrition 5*, 440–4 (1957).

Rutabaga and turnip are the only edible plants from which an active goitrogen has so far been isolated. The active antithyroid agent in these vegetables has been identified as goitrin. Goitrin is apparently liberated from progitrin only by a thioglycosidase contained in the plant or seed itself. Cooking destroys this enzyme and thus negates its goitrogenic potency. Although the ingestion of considerable quantities of goitrogenic foods may contribute to the development of goiter under certain circumstances, it is very difficult to incriminate them as an etiologic factor in the vast majority of goitrous patients.

The edible snail.

CADART, *J. Sci. American 197*, 113–18 (1957).

The French now eat more than 8000 tons of snails in a year. From the gastronomical point of view the richest and most delectable part of the snail is the upper portion, coiled within the spiral of the shell. The snail largely owes its savor, easy digestibility and nutritive value to the liver. Ounce for ounce the snails' visceral mass contains more protein, fat and mineral salts than beef or fish. The cultivation and shipping of snails for consumption as a human food is discussed.

Pharmacology and Toxicology

The sterilization of plastic intravenous injection equipment by ethylene oxide vapor.

GRUNDY, W. E., RDZOK, E. J., REMO, W. J., SAGEN, H. E. AND SYLVESTER, J. C. (Abbott Labs. Research Div., North Chicago, Ill.). *J. Am. Pharm. Assoc., Sci. Ed. 46*, 439–42 (1957).

Intravenous injection equipment composed entirely of plastic is readily sterilized in the shipping carton by ethylene oxide vapor. Sterility was achieved in 4 hrs. but not in 2 hrs. with a temp. of about 75° F. and a gas pressure of 0.5 atm. A technique for contaminating and for making quant. measurements of organisms killed was developed. The basis of this method is a filter paper test strip impregnated with spores of *Bacillus globigii* A. T. C. C. 9372. The ethylene oxide vapor adsorbed by the plastic and the package has a marked sterilizing effect after the material was removed from the chamber. The expts. carried out in this study were designed to minimize this effect. Under practical conditions, the adsorbed ethylene oxide provides an addnl. safety margin in the sterilization process.

Physiology and Medicine

Oat extract for teeth.

ANON. *Food Eng. 29* (5), 126 (1957).

A group of 10 phenol-type compds. and fatty acids, extd. from finely ground oat hulls, have been shown to give good protection against teeth cavities. The specific chemicals have not been isolated.

Specificity of a glucose oxidase test for urine glucose.

ADAMS, E. C., BURKHARDT, C. E. AND FREE, A. H. (Miles-Ames Research Lab., Elkhart, Indiana). *Science 125*, 1082–3 (1957).

In this test, glucose is oxidized to gluconic acid and hydrogen peroxide, the reaction being catalyzed by the enzyme. The hydrogen peroxide oxidizes orthotolidine in a reaction catalyzed by peroxidase. The enzymes and indicator are impregnated on a stick of stiff filter paper. The detection of glucose in urine is readily accomplished by dipping the test stick in the urine sample and observing at the end of 1 min. Development of a blue color denotes the presence of glucose; the test is negative if no blue is seen at 1 min. One of the outstanding features of the test compn. is its specificity in detecting glucose as differentiated from other reducing sugars or nonglucose reducing substances. This report describes studies that establish the high specificity of this test.

Evidence that histamine is a gastric secretory hormone in the rat.

SCHAYER, R. W. AND IVY, A. C. (Univ. Illinois Coll. Med., Chicago). *Am. J. Physiol. 189*, 369–72 (1957).

The results provide decisive evidence that the ingestion of a meal by a fasting rat causes the release of bound C^{14} histamine.

(Abstracts continued on page 66)

TYGON B44-3

food and beverage hose

The Golden Age Beverage Co., Inc., of Akron, Ohio, franchised bottlers and distributors of Pepsi-Cola, use Tygon Formulation B44-3 Transparent Flexible Plastic Tubing extensively in their Pepsi-Cola operation. Liquid sugar and syrups are piped to process vats, prepared mixes are pumped to storage tanks . . . all through 2″ i.d. x 2½″ o.d. Tygon B44-3 Food and Beverage hose.

Tygon B44-3 Tubing was chosen for this operation because of its many outstanding advantages over other piping mediums. For example, because it is non-contaminating and totally inert to food acids and alkalis, there is no possibility of flavor taint or odor resulting from its use. Its glass-like clarity enables operators to visually check contents at any point.

Tygon B44-3's flexibility makes it adaptable to any layout. It can be used in long continuous runs without extra joints or couplings, and if desired, hoses may be interchanged or simply moved from one application to another. The highly polished bore permits fast, thorough cleansing—Tygon lines may be uncoupled, washed or steam flushed — and be back in service in minutes. Fifty-five bore sizes from 1/16″ to 3″ i.d. insure a size for every need.

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INDUSTRY PUBLICATIONS

Dairy storage tanks—both cylindrical and rectangular types—are the subject of Bulletin 943 just issued by the Pfaudler Co., 1043 West Ave., Rochester, N. Y. The 12-page bulletin includes step-by-step construction details, a discussion of the Pfaudler Stream-Flo agitator, a section devoted to refrigerated storage tanks, and complete dimensions and specifications for all models.

Mold and rope inhibitors, calcium and sodium propionate, are described in a new brochure published by Eastman Chemical Products, Inc., Kingsport, Tenn. Included are typical analyses of the two inhibitors, a discussion of their use in various bakery products, and mold-free storage life data on commercial white bread prepared with varying amounts of the inhibitors.

Information on **thioglycolic acid** "never before published under one cover," according to the publisher, is in a new 20-page catalog issued by Evans Chemetics, Inc., 250 E. 43rd St., New York 17. Contents include properties and specifications of the acid, its reactions and uses, and an extensive bibliography. Copies are available free of charge when requested on company letterhead.

The merchandising convention and exhibition of the National Frozen Food Dealers Association, held in Chicago early in September, included an exhibit booth devoted to results of the **time-temperature-tolerance project** at the Western Regional Research Laboratory of the U. S. Department of Agriculture. Reports on the project are being published in FOOD TECHNOLOGY. The purpose of the exhibit, according to the *Information Bulletin* of the Refrigeration Research Foundation, was to give visitors a first-hand knowledge of the kinds and degrees of damage to food quality that result from exposures at various temperatures for varying periods of time. Three project leaders were to exhibit samples and discuss damage resulting from exposure to improper temperatures.

The second volume of **The Freezing Preservation of Foods** has been published by the AVI Publishing Co., 7 Taylor Pl., Westport, Conn. Entitled *The Freezing of Precooked and Prepared Foods,* this book, together with volume 1, *The Freezing of Fresh Foods,* covers the frozen food industry from the principles of quick freezing and refrigeration to the freezing of precooked specialty items and TV dinners. The authors are Donald K. Tressler, scientific director of the Quartermaster Food & Container Institute for the Armed Forces, and Clifford F. Evers, technical service director of Ac'cent-International Div. Price of the set is $28 in the U. S., $30 in foreign countries. The volumes also are available separately. Volume 1 is $18 in the U. S., $19 foreign; volume 2 is $10 in the U. S., $11 foreign.

Metal-probe thermometers of two basic types are described in a new folder available from Royco Instruments, 720 Arthur St., Albany 10, Calif. The two models listed are the integral-probe type with the electrical indicating instrument mounted directly on the rigid probe, and the remote-probe type in which the indicating instrument is in a separate case and the probe is on the end of a flexible cable. The folder also covers accessory equipment such as probe extensions, a sliding-nipple arrangement for scanning measurements on fluids in pipes, and special remote panel-mounted instruments.

Office and factory equipment, plus new products which have been devised recently as aids for executive planning, are in a new catalog issued by Precision Equipment Co., 4411C Ravenswood Ave., Chicago 40.

You and Labor Law, a two-part, 30-minute sound slide-film in color, describes the history, purpose and principles underlying our present labor law. Part I shows the evolution of labor law philosophy and precepts, while the second part shows our present labor law in action. The slide-film is for sale through the Employers Labor Relations Information Committee, Inc., 33 E. 48th St., New York 17.

Safety equipment of all types—from a half-ounce dust mask to a large barrel lifter—is described and illustrated in a new catalog, No. 10, published by General Scientific Equipment Co., 7516 Limekiln Pike, Philadelphia 50. Equipment is grouped according to its function so that the reader can compare similar products and select the ones best suited to his needs. Product descriptions are completely factual and sufficiently detailed to permit proper choice.

Properties and uses of **Oakite Drycid,** the recently introduced powdered-acid scale and rust remover, are described in a service report published by Oakite Products, Inc., 19 Rector St., New York 6. The report emphasizes the convenience in shipping, storing and using powdered rather than liquid acid, and the material's greater safety when used on various metals.

A new **coffee urn thermostat** for commercial gas-fired coffee makers is fully described in a bulletin available from the Robertshaw Thermostat Div., Robertshaw-Fulton Controls Co., Youngwood, Pa.

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Bulletin RT-816 contains a detailed cut-away diagram of the control, designated Model GC, a rod-and-tube control rated at 49,500 BTU for manufactured gas, 73,200 for natural gas and 157,000 for L-P gas.

How do children grow? Icie G. Macy and Harriet J. Kelly, both members of the staff of the Merrill-Palmer School in Detroit, offer a new answer to this question in *Chemical Anthropology,* recently published by the University of Chicago Press, 5750 Ellis Ave., Chicago 37. By extending the scope of physical anthropology to include chemical growth and its relation to physical growth and physiological function, the authors have developed a new concept that they call "chemical anthropology." Their book correlates the wealth of experience and data attained in this field by pediatricians, anatomists, roentgenologists, nutritionists and statisticians.

The advantages of using **Johns-Manville asbestos papers** to protect against fire, heat or corrosion are outlined in a brochure, EL-92A, available from Johns-Manville Sales Corp., 22 E. 40th St., New York City. The brochure also includes a chart showing the thickness, weight, tensile strength, tear strength and bursting strength of all J-M commercial and fibroid asbestos papers. Eight different types of J-M papers, suitable for use in many types of industry, are explained in the folder, together with a listing of the forms and dimensions in which each is available.

The Future of Food Preservation, the proceedings of a symposium held early this year, is still available in limited quantities, at $6 per copy, from Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo. Contents include 11 papers on such subjects as "Refrigeration and Freezing," "High Energy Preservation," "The Economics of New Food Processing Methods," and "Nutrition and Food Preservation Methods of the Future."

(Continued on page 62)

EQUIPMENT

Rate-of-Change Indicator. A new development in electro-mechanical computers, termed a "thinking indicator," now is available for accurate measurement and continuous indication of rates-of-change at values too slow or too small for conventional measuring methods.

Called the Deltameter, the instrument has an output signal representing millivolts/second/second, visually shown on a calibrated meter; the output also may be fed into a recorder or a control system. Input voltages may represent pressure, temperature, pH, light intensity, velocity, or contact potential. Additional information on the Deltameter can be obtained by writing Miljan, Inc., Box 396, Paramount, Calif.

Industrial Gloves. Designed especially for use with aromatic and aliphatic hydrocarbons, the new Wil-Gard Buna-N synthetic rubber gloves have been introduced for the protection of industrial workers. The gloves are said to have remarkable resistance to virtually all industrial greases, oils, solvents and chemicals. Information on the various sizes and weights available can be obtained from the Wilson Rubber Co., Industrial Div., 1200 Garfield Ave. S. W., Canton 6, Ohio.

Oxidation Stability Test. In its search for a more precise method for evaluating the effectiveness of its line of Tenox food-grade antioxidants, Eastman Chemical Products, Inc., Kingsport, Tenn. has

developed a new, accelerated test to determine the oxidation stability of fats and oils. The test is based on a modification of the standard ASTM oxygen bomb method by which gasoline stabilities are compared.

Basically, the method involves placing the fat, oil or finished food under 50 or 100 p.s.i. of oxygen, raising the temperature to 212° F., and recording the time required for a significant pressure drop to occur. The test is carried out in a glass-lined, chrome-nickel alloy steel bomb which is immersed in a boiling water bath. The combination of pure oxygen, high pressure and elevated temperature accelerates the oxidative deterioration of the material being tested.

The company, which offers details of the new test, says that statistical analyses of the active oxygen method, the Schaal oven test and the new oxygen bomb method show the last-named to be much more precise than either of the others.

Molecular Still. The new, 2-in. Rota-Film molecular still, which accommodates continuous or batch feeds of from 10 ml. to 20 liters, has been introduced for such applications as evaporation and dehydration of organic compounds, concentration of solids in solution, reduction of solutions to dry powders in a single operation, and deodorizing oils. It distills hydro-

RY-ZING! puts zing in sales of your rye products!

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. . . to increase the volume of your profitable rye sales **RY-ZING!** imparts the full rye taste, aroma, texture, crust and color that adds taste-appeal . . . eye-appeal and sales appeal to your rye bread, rolls, salt sticks and rye rusk.

Here is our exclusive formula for **RY-ZING!** rye bread.

SPONGE	LAB. FORMULA
Clear flour	60 lbs.	300 gms.
Water (Variable)	44 lbs.	220 cc.
Yeast	2 lbs.	10 gms.

METHOD

Dissolve the yeast in the water, place the flour into machine. Add the yeast solution and mix smooth. The dough should be 78°-80°F. Ferment four hours and return to mixer.

DOUGH	LAB. FORMULA
Rye flour	40 lbs.	200 gms.
Water (Variable)	26 lbs.	130 cc.
Salt	2½ lbs.	12.5 gms.
RY-ZING!	1 lb.	5.0 gms.

METHOD

Add the water, salt and **RY-ZING!** to the sponge, and stir to break up. Add the rye flour and mix until uniform. Let dough rest 30 minutes. Divide, give 30 minutes intermediate proof, and make up.
Proof and bake at 425°F., with considerable steam in the oven.

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Use it in your production for ten days.
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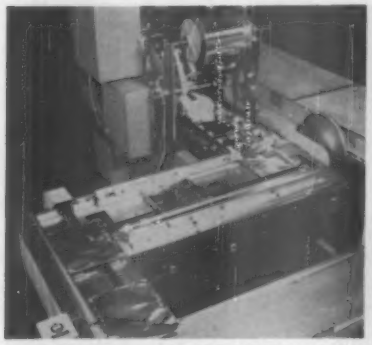
carbons with molecular weights ranging from 200 to 1250, and silicones and halocarbons with weights as high as 4000. Materials are fed into the Rota-Film at their melting point, and since the entire procedure is complete in less than one second, molecular changes are said to be minimized and pure distillates are obtainable.

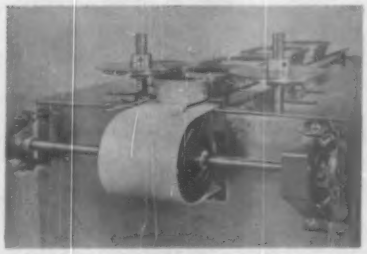
Details on the Rota-Film can be obtained from Schaar & Co., 7300 W. Montrose Ave., Chicago 34.

Aluminum Package Developments. Four new developments in packaging equipment and aluminum containers, promising substantial savings for food processors, were shown recently by the Foil Kraft Div. of Kaiser Aluminum & Chemical Sales, Inc., at the National Frozen Food convention in Chicago.



Foilcrimp top sheet wrapping machine for aluminum trays and other open rectangular containers cuts top sheets from roll stock (top), crimps them tightly by means of nylon rollers along edge of conveyor belt.

The developments include the Foilcrimp machine, which applies flexible aluminum foil top sheets to a wide variety of open rectangular containers and trays at speeds said to be far above conventional production line standards. Related to the Foilcrimp machine is a new tray depositor developed to provide a mechanical means of feeding compartmented frozen-food trays onto a filling line conveyor belt.



Rotocrimp closing unit for rigid aluminum foil containers operates without using dies, closes packages with rotating "plows" as containers move continuously along conveyor at speeds of more than 100 per minute.

Another piece of equipment, the Rotocrimp unit, introduces a continuous-motion closing principle for aluminum containers which does away with the need for closing dies. The fourth development introduced at the convention was a line of containers with extra-high vertical rims of curled foil which are said to eliminate the cut-finger hazard, crimp more satisfactorily, and provide a firmer grip on the package top.

Details can be obtained from Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11.

Mirror Galvanometer. The Hilger Galvoscale is a self-contained mirror galvanometer, housed in a compact cabinet with a special vibration-resistant mounting. Designed to stand on any reasonably firm bench or table, the instrument can be used at any convenient location in the laboratory. Although it requires bench space of only 12 by 21 inches, the Galvoscale has an effective length of scale equal to that given by an optical lever of two meters. The instrument is equipped with the purchaser's choice of galvanometers in three sensitivity ranges. Full details are in catalog CH350/4, which can be obtained from the distributor, Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

(Continued on page 62)

PRODUCTS

Flavor Intensifier. Dodge & Olcott, Inc., recently announced development of Flavotang, a flavor intensifier recommended for use in processed meats, frozen foods, stews, soups, gravies and related items. The product is available in several forms containing varying amounts of monosodium glutamate and a blend of spice extractives on a carrier. Specific usage will vary with the end product and the particular flavor characteristic desired. The company says that excellent results generally will be obtained within a range of 6–12 oz. per 100 lb. of finished product. Specifications, prices and trial quantities can be obtained from the company at 180 Varick St., New York 14.

Modified Starch for Frozen Foods. The development of Freezist, a new, tasteless modified starch, reportedly will enable the frozen food industry to overcome the serious problems of "weeping" and unacceptable texture changes that have blocked consumer acceptance of certain frozen food items. These defects usually are caused by liquid separations and retrogradation that develop when ordinary starches are used in precooked frozen foods. Products incorporating Freezist as a base thickener are said to retain a freshly cooked taste and appearance and require less time for reheating.

The manufacturer, Morningstar, Nicol, Inc., 630 W. 51st St., New York 19, claims that Freezist eliminates "weeping" and texture changes in thawed foods even after extended freezer storage or varying

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The many uses for our products in the dairy products and baking industries are being swelled by a growing demand from other food processors, notably manufacturers of canned and packaged specialties.

The versatility of our materials has enabled our Technical Department to help in the creation of better, and in some instances, altogether new food products.

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Canadian Sales Representative — Charles Albert Smith Ltd.
366 Eastern Ave., Toronto 8 • 8307 Royden Road, Montreal 9

freeze-thaw conditions; it is completely compatible with food acids in all kinds of foods.

Emulsifier for Cakes. American Breddo Corp., 601 W. 26th St., New York 1, has announced the introduction of Brem, a new concentrated emulsifier for sponge cakes and regular cakes which contain shortening. Brem is said to simplify mixing procedure and reduce mixing time, and cakes made with it have a close, fine texture and remain moist for days longer. The product is available in 35-lb. pails and 400-lb. drums.

EXPANSION NEWS

Pennsalt Chemicals Corp. has selected a ten-acre area near Oakville, Ont., as the site of its first plant in Canada. As part of Pennsalt Chemicals of Canada, Ltd., a wholly owned subsidiary, the new unit will facilitate distribution of Pennsalt chemical specialties not now available in eastern Canada. Initial product lines will include metal processing chemicals, sanitizing agents for food processing and dairy plant operations and numerous other Pennsalt and Sharples brand products. The one-story brick plant, already under construction, is expected to be completed in December.

American Can Co. has announced that its research and technical department has established an aluminum division to find practical, low-cost methods of manufacturing aluminum alloy into commercial containers. William C. Stolk, company president, said the research department has been working on the development of aluminum containers for several years and has perfected techniques for producing both aluminum alloy and aluminum-coated steelplate cans on a pilot line basis.

GEORGIA MOVES FORWARD IN FOOD TECHNOLOGY. The special grant of $2,840,600 which Gov. Marvin Griffin (right) recently made for completion of the University of Georgia's $12,000,000 Science Center means progress in food technology in the state and region. The Science Center will make possible an expanded and coordinated program in research and teaching. Shown here with Governor Griffin looking at final plans is Dr. J. G. Woodroof, chairman of the food processing division, and Dr. J. J. Powers, head of the food technology department—both IFT members.

Also located in the Center will be buildings to house physics, chemistry, biology, animal industry, poultry, mathematics, and geography and geology. This is the second special grant which Governor Griffin has made for Science Center. Last summer he gave the University $5,000,000.

MEMORANDA

After an interruption of a year, the American Oil Chemists' Society plans to resume its series of **annual short courses.** Dr. Karl F. Mattil, chairman of the AOCS education committee, has announced that Dr. Foster Snell has agreed to serve as general chairman for a short course next summer. Present plans are for a course on soap and syndets in July 1958, probably at Rutgers University. Information on the program and registration procedures will be released later.

Reynolds Metal Co. planned to begin in September an intensive advertising program designed to introduce both the baking industry and the general public to the advantages of **foil wraps for bread.** The campaign was to be built around a full color advertisement in the September 9 issue of *Life*, and included plans for trade magazine ads, television commercials, and point-of-sale advertising. Presently less than 1% of bread sold is packaged in aluminum foil. Reynolds, however, produces printed aluminum foil overwraps for 13 different bread items of eight major bakeries, and predicts increasing use of foil for bread. Advantages claimed for the foil wraps include prolonged shelf-life, greater freshness and vitamin retention, and better taste.

Secretary of Defense Charles E. Wilson announced recently that McCormick & Co., Inc., Baltimore spice and extract house, will receive the **Department of Defense Reserve Award** "for splendid service to our country." Writing to Charles P. McCormick, board chairman, Secretary Wilson expressed the Department's "appreciation for the outstanding cooperation with reservists and reserve activities achieved through the personnel policies you have established. Your continuing support of the Reserve program is warmly appreciated by the Defense Department and will serve

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SHEFTENE Milk Proteins are wholesome, edible products of high-quality, balanced protein content, capable of supporting growth and maintaining nitrogen equilibrium.

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SHEFTENE C2 Edible Casein Flour (soluble form), and SHEFTENE C2 Edible Casein . . . to improve nutritive value of bakery products, flour, cereals.

SHEFTENE Calcium Caseinate . . . for supplementation of bakery products, flour, cereals; pharmaceutical, infant food and dietetic preparations.

SHEFTENE 60 . . . an excellent oral supplement for dietary foods and geriatric diet preparations.

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as an example for other companies."

The Reserve Award is made by the Defense Department only after long study of company policies toward reservists, including the allowance of time off with pay for reservists going on tours of active duty, hire of reservists without discrimination, and general support of reserve and National Guard programs.

A $5 million display of air conditioning and refrigeration equipment of all types will be the highlight of the **10th Air Conditioning & Refrigeration Exposition** at Chicago in November. The show, sponsored by the Air Conditioning & Refrigeration Institute, will be held in Chicago's International Amphitheatre Nov. 18 to 21. More than 250 companies will display some 7,500 pieces of equipment and components, and about 20,000 executives from a broad cross-section of the industry are expected to attend. This year, for the first time, the general public will be admitted on the last day of the show.

The Poultry Products Inspection Act, which calls for compulsory inspection of poultry by the U. S. Department of Agriculture beginning Jan. 1, 1959, was lauded recently by Dr. Cliff D. Carpenter, president of the Institute of American Poultry Industries. "The President and Congress are to be congratulated on the mandatory inspection bill which has been made law," Dr. Carpenter said. "The poultry industry has been successful in getting a bill that is workable for the industry and a protection for the consumer."

The new law does not apply to poultry shipped intrastate, except in certain areas that may be designated by the Secretary of Agriculture, nor to live poultry, eggs and egg products, game birds or squabs. Specific exemptions also are provided for producers who process their own poultry and sell direct to consumers or institutions, and for poultry processed in accordance with religious dietary laws.

Ante-mortem inspection will be performed to the extent deemed necessary by the Secretary of Agriculture. Post-mortem inspection will be performed on each carcass processed, and in this connection the House of Representatives' report said, "the Secretary shall at all times provide sufficient inspectors and employ such procedures as will not slow down processing operations in the plants being inspected."

Processors may apply for inspection at government expense after Jan. 1, 1958, even though inspection does not become mandatory until 1959.

PERSONNEL

Dr. Roy E. Marshall was elected Secretary-Treasurer and Business Manager of the American Society for Horticultural Science at the 54th annual meeting held in connection with the meetings of the American Institute of Biological Sciences at Stanford University.

Membership in the ASHS now exceeds 2000 members, most of whom are staff members of universities and colleges, and federal and state agencies. Heretofore the Editor of the proceedings was also Business Manager. Now there will be an editor for the two volumes of proceedings published each year and all business matters will be handled by the office to which Dr. Marshall has been elected. His office will be at East Lansing, Michigan.

R. E. Marshall

Dr. Marshall, IFT member long active in its councils and activities, retired as a staff member of Michigan State University September 30, 1957 after 37 years of service. He was Professor of Horticulture for 30 years, served also as Chairman of Food Technology from 1944 to 1950, and during the past seven years has been Assistant Director of the Michigan Agricultural Experiment Station.

John T. Knowles and **Guy V. Graham,** two Libby, McNeill & Libby executives who have retired after long service with the company, were honored recently by company officials at a testimonial dinner in Chicago. Mr. Knowles, who joined the company in 1910, was vice-president in charge of research and quality control before his retirement; he is a member of IFT. Mr. Graham ended a business career of 41 years with the company on Sept. 30; he had been vice-president in charge of salmon operations since 1952. Mr. Graham's headquarters was in Seattle, while Mr. Knowles's office was in Chicago.

J. T. Knowles

Theodore T. Miller, president of the Polymer Chemicals Div. of W. R. Grace & Co., has been named vice-president in charge of the marketing division of the American Management Assn. **Roger H. Lueck,** vice-president of American Can Co. has been appointed to a three-year directorship of AMA, and **C. L. Rumberger,** vice-president in charge of the Research & Quality Control Div. of H. J. Heinz Co. has been reelected as a vice-president of AMA. All are IFT members.

V. R. Van Natta and **Henry Kohorn** have been elected vice-presidents of Consolidated Foods Corp. Mr. Van Natta is president of Consolidated's Monarch Finer Foods Div., while Mr. Kohorn is president of E. A. Aaron & Bros., Inc., a Consolidated subsidiary.

Lawrence D. Starr has been appointed director of research for Koch Supplies, Kansas City, Mo. An IFT member, he is a graduate of California Institute of Technology and took his master's degree in food technology at MIT.

Mr. Henry D. Tefft, Chairman of the D & O Achievement Award Comittee and Director of the Dept. of Packinghouse Practice of the American Meat Institute presents award to Mr. Laurence W. Murphy (left) of Geo. A. Hormel & Company. Duplicate awards were given for 1957. Mr. Leonard T. Force of Canada Packers, Toronto, Canada, received the sister award.

Dr. William G. Gordon has been named to receive the 1958 Borden Award in the Chemistry of Milk. Dr. Gordon, a supervising chemist at the Eastern Regional Research Laboratory, Wyndmoor, Pa., is in charge of the protein structure unit of the laboratory's animal protein section. The Borden Award consists of $1,000 and a gold medal.

W. G. Gordon

Dr. Kenneth W. Gardiner has been named to head the general chemistry laboratory in the new Central Research & Engineering Div. of Continental Can Co., and **Dr. Charles J. Spiegl** will be in charge of the toxicological laboratory. Dr. Gardiner formerly was director of the research laboratory for Gardiner Instrument Co., Cambridge, Mass., while Dr. Spiegl was associated with the AEC at the University of Rochester for 15 years before joining Continental.

Dr. John H. Litchfield has been named asisstant professor of food engineering at Illinois Institute of

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Bakers find Staley's Sta-Sol® Lecithin improves dispersion and emulsification of fat, and reduces stickiness of dough. Candy makers use it also to disperse fat and to give better eating and keeping qualities. In chocolate, it reduces viscosity, increases covering power and stabilizes the coating.

Sta-Sol Lecithin works in margarine, lard and shortenings as an emulsifier and antioxidant.

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Technology, Chicago. He formerly was a research food technologist for Swift & Co. and during 1950–53 was food adviser to the major commands in the U. S. Army both in the U. S. and in Germany.

Robert W. Bond has been appointed manager of the sales service department of Corn Products Sales Co., and **T. C. Clawson** has been named assistant sales manager of the company's central division office in Chicago. Another Corn Products executive, **Henry C. Frost,** assistant chief engineer, recently was chosen president-elect and secretary of the Instrument Society of America, of which he is a charter member.

Robert W. Bond

Leo Bernstein, formerly with Standard Brands, Inc., has been appointed as a senior research chemist with Evans Research & Development Corp., New York City. **Gertrude Gilman,** research chemist, and **Pasquale Bilello,** assistant research chemist, also have joined the Evans Research staff.

Eastman Chemical Products, Inc., Kingsport, Tenn., has embarked on an "exchange of duties" training program designed to meet the company's need for men with broader knowledge and experience in all phases of its activities. The first exchange under the program involves J. H. Sanders, the chemical division's Cleveland district manager, and R. W. Miller, who is product manager for all industrial chemicals made by Kodak's Texas Eastman division in Longview, Tex.

Knickerbocker Mills Co., New York City, has appointed the Fleck Co., Houston, as its broker for the southern Texas area.

Charles L. Gunn recently joined the exploratory development staff of the Research & Development Dept. of the Procter & Gamble Co., Cincinnati.

Lawrence R. Keenen is the new eastern regional engineering manager for the Systems Div. of Beckman Instruments, Inc. He will make his headquarters at the company's Mountainside, N. J., plant.

Albert I. Kegan returned recently from a European tour during which he and Mrs. Kegan were delegates to the international meeting of the American Bar Assn. in London. Mr. Kegan was the only professor of food law endowed by the Food Law Institute to attend the London meeting. On their return, the Kegans announced the admission to their partnership of **John I. Bellamy,** former head of the patent department of the Kellogg Switchboard & Supply Co. The firm name has been changed to Kegan, Bellamy & Kegan.

John T. Bricker has been appointed manager of the Los Angeles branch office of Dodge & Olcott, Inc. Active in the essential oils industry for more than seven years, Mr. Brickner, an IFT member, formerly was with Vitaminerals, Inc., Glendale, Calif.

Dr. Albert H. Cooper has been appointed general manager of American Industrial Chemical Co., a division of Amerace Corp., Butler, N. J. Dr. Cooper directed development of the continuous process now used for making silica gel and other silicas at the Butler plant.

Albert H. Clarke has been named vice-president in charge of manufacturing for Crouse-Hinds Co., Syracuse, N. Y., and **Russell P. Northrup** has succeeded Mr. Clarke as vice-president in charge of engineering. Mr. Northrup formerly was commercial vice-president in charge of Condulet sales.

Heloise Parker Broeg has been appointed director of the newly formed consumer service department of Coastal Foods Co., Cambridge, Md., a division of Consolidated Foods Corp. During the past 16 years, Mrs. Broeg conducted a daily program over station WEEI, Boston, and she conducted the first cooking program on television for CBS in New York.

Mrs. Broeg

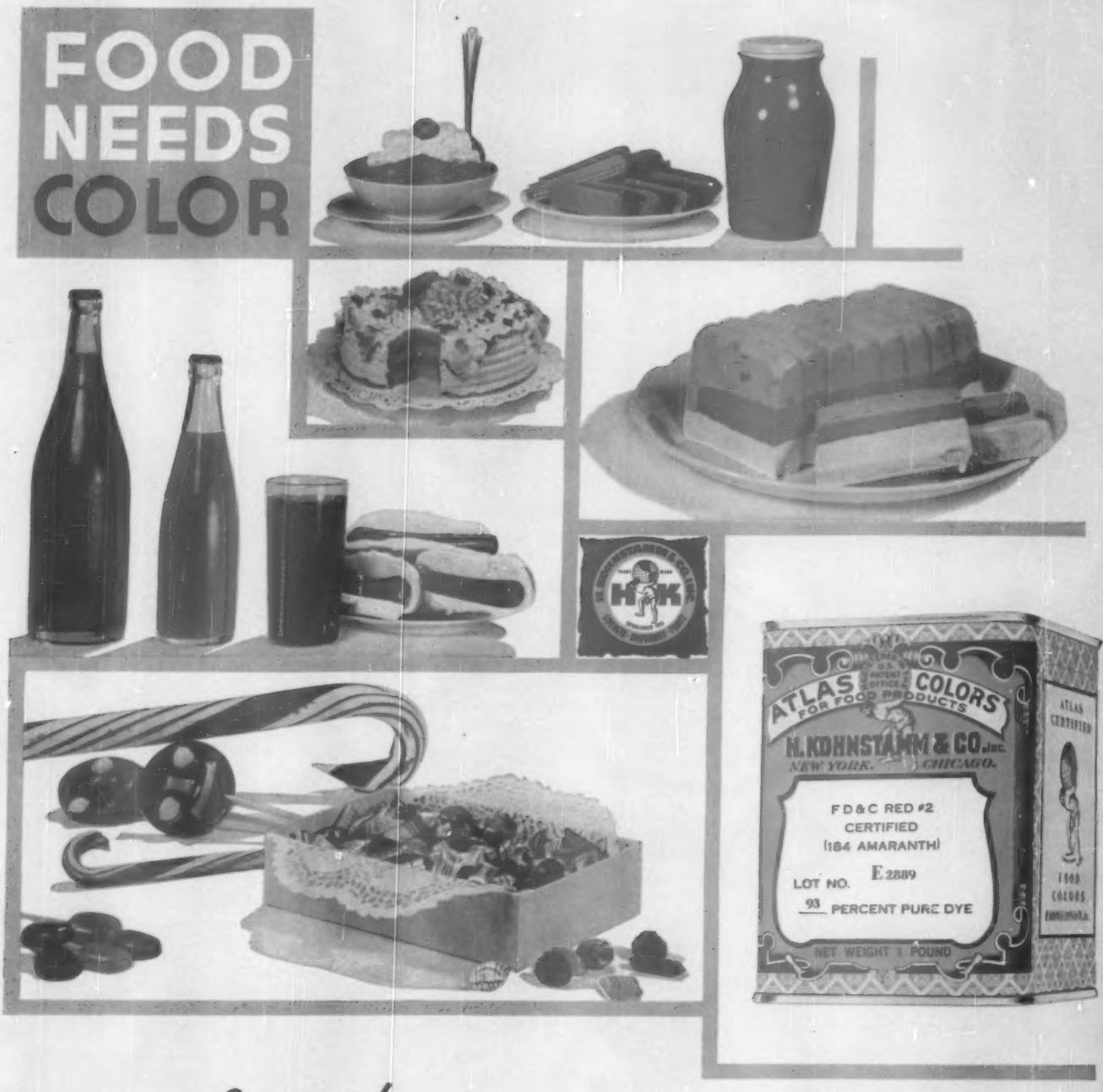
Walter T. Blake, manager of the research and development department of Pillsbury Mills, Inc., Minneapolis, has resigned to become vice-president and general manager of C. W. Brabender Instruments, Inc., South Hackensack, N. J.

Expansion News

(Continued from page 56)

The Sharples Corp., Philadelphia, recently announced the formal opening of the new factory and offices of its wholly owned English subsidiary, Sharples Centrifuges, Ltd., at Camberly, Surrey. Known as the Tower Works, the new buildings, located on a three-acre site, provide for substantially increased manufacturing, research and test-

FOOD NEEDS COLOR



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ing facilities. C. Peter Balfour is managing director of the English company, which formerly was located at Stroud, Gloucestershire.

Aluminum Company of America has announced plans for what it calls the nation's first fundamental research facility to serve the foil and packaging industries. Representing a consolidation and expansion of the company's research operations in these fields, the new facility will be known as the Foil & Packaging Div. of Alcoa Research Laboratories, and it will be located at New Kensington, Pa.

EverSweet Corp., of Frostproof, Fla., and Lyons, Ill., is completing an equipment expansion program at its Florida processing plant designed to enable the company to double its production of fresh chilled orange juice. At the same time, the company reported that its sales in the Chicago area increased 60% during the first eight months of 1957.

L. Sonneborn Sons, Inc., plans expansion of its microcrystalline wax plant at Petrolia, Pa. to include facilities for the manufacture of oxidized microcrystalline waxes, used in the manufacture of emulsion polishes. Included in the design of the plant will be facilities to prevent the mild odor of these waxes from contaminating other microcrystalline waxes which are used in food packaging.

Stephens-Bangs Associates, Inc., is the name of a new food facility engineering organization in Detroit. The new company resulted from the merger of J. E. Stephens Associates, Inc., and O. Ernest Bangs Associates.

Consolidated Foods Corp., Chicago, has sold the can-making facilities of its Coastal Foods Div. to the National Can Corp. Located at Cambridge, Md., the plant contains 11 can-making lines with a capacity of 3,000,000 cans per day.

Flavor laboratory personnel of Fritzsche Bros., Inc., are shown at one of the monthly flavor technology seminars recently begun for the New York firms' executive staff. The seminars are under the direction of IFT member Harold L. Janovsky, chief flavor chemist, and this session was led by another IFT member, Fred Wesley (standing), one of the firm's pharmaceutical flavor specialists. The company may invite customers to future seminars.

Publications

(Continued from page 53)

Food and drug **uses for safflower oil,** the most highly unsaturated vegetable oil commercially available, are discussed in a brochure published by Pacific Vegetable Oil Corp., 62 Townsend St., San Francisco. The report covers physical and chemical properties, uses in foods, and the supply situation.

Bulk materials handling with equipment produced by the Tote System, Inc., Beatrice, Neb., is discussed in a 20-page catalog, No. 6, just issued by the company. The catalog describes and illustrates automatic filling and discharge stations, inter- and intra-plant applications of Tote equipment, and specifications of the equipment.

License to use a public-service patent on preparation of the modified fats known as **acetoglycerides** has been granted by the U. S. Department of Agriculture to Beacon Chemical Industries, Inc., Cambridge, Mass. The patent originally was issued to Agricultural Research Service scientists Reuben O. Feuge, Earl J. Vicknair and Klare S. Markley for work done at USDA's Southern Utilization Research & Development Div. in New Orleans; it was assigned by them to the Secretary of Agriculture for public use.

Development of production processes for acetoglycerides is said to offer many new possibilities for industrial use of animal and vegetable fats. Some of the products are flexible, wax-like and nongreasy in texture. Their melting points can be varied for special requirements, and they also are resistant to oxidation and rancidity.

Reprints of technical papers dealing with acetoglycerides can be obtained free from the Southern Utilization Research & Development Div., USDA, Box 7307, New Orleans 19.

Equipment

(Continued from page 55)

Automatic Colorimeter. An automatic balancing and recording colorimeter, known as the ABARC, now is available from Mission Instruments Co., Box 801, Glendale 5, Calif. Its function is primarily absorption measuring for colorimetric determinations on transparent liquids, glass and plastics over a spectral range of 400–800 millimicrons. Advanced features, according to the manufacturer, include automatic balance, greater accuracy, better sensitivity, faster results, and a longer light path for samples of low absorption.

ABARC Model 3 is constructed for either laboratory or field use and is not affected by humidity, temperature or vibration. Another model, 3R, modified for connection to any external, self-balancing recorder, also is available. Details

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Quaker can provide flours or thickeners with very mild or bland flavors which will not mask or obscure the flavors and odors of your product. Conversely, Quaker can produce meals and flours with slight toasted or popcorn flavors. These are often desirable flavor notes for canned chile, chowder, catsups, sauces, etc.

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are in a brochure that can be obtained from the company.

Biological Particle Disintegrator. American Instrument Co. has announced a new instrument, the French pressure cell, for disintegrating chloroplast material, blood cells, unicellular organisms, homogenates of animal tissue and other biological particles. The French cell permits destruction of cellular walls while leaving the cell nucleus undisturbed.

Operation is said to be safe, simple and rapid, and produces highly accurate results. A specified amount of sample is placed in the unit, and the air is removed. The unit is then placed in a hydraulic press where pressures up to 20,000 p.s.i. are applied and then suddenly released. Cellular walls literally explode, but the nuclei are unaffected.

Additional information is in Bulletin 2291, published by American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.

X-Ray Diffractometer. A new Norelco X-ray diffractometer incorporates a number of design changes that reportedly extend the sensitivity, accuracy and application range of the instrument. Developed especially for X-ray powder diffraction work, the unit can accommodate high and low temperature chambers, devices for preferred orientation and pole figure studies, focusing monochromators and similar accessories. The assembly consists of the basic X-ray generator and tube; wide-range goniometer with detector; and electronic circuit panel with strip-chart recorder. The goniometer accommodates scintillation, proportional, flow or Geiger counter units to provide a wide choice of detectors for all conditions.

Complete operating specifications can be obtained from the Instruments Div., Philips Electronics, Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

Centrifugal Liquefier. A unit that rapidly melts frozen cream, butter, and eggs, the Bryant centrifugal liquefier, has been designed to improve quality and cut costs in the manufacture of butter, ice cream, sour cream, cream cheese and sterile milk oil. The unit is said to have a capacity for melting 3,000 lb. of 50% frozen cream or 2,000 lb. of butter per hour. The rapid action of the machine reportedly eliminates the possibility of oxidized fat and subsequent poor-quality products.

The centrifugal liquefier operates by transferring latent heat of condensing steam to the frozen fat through a rapidly revolving disk. Frozen cream is loaded onto the heated disk, and melted cream is thrown by centrifugal force against a surrounding ring and runs by gravity to the collecting trough. Specifications are available from S. Blickman, Inc., 8400 Gregory Ave., Weehawken, N. J.

Liquid-Nitrogen Refrigerator. Linde Co. has introduced a compact, efficient liquid-nitrogen refrigerator for laboratory and industry use. The unit consists of a double-walled, stainless steel jacket, insulated with a special vacuum-powder combination. The inner container is filled with liquid nitrogen, which has a temperature

of −320° F., and accessory storage baskets filled with material for freezing are lowered into the liquid nitrogen. The refrigerator, called the LNR-25B, then will hold material at a constant temperature of −320° as long as liquid nitrogen, in any quantity, is present. A single charge of liquid nitrogen is said to last up to 34 days. The unit weighs 60 lb. empty, 115 lb. fully charged.

Linde also offers a larger model, the LNR-640B, designed to keep 17½ cu. ft. of product at −320° for as long as 100 days on a single charge. Details on both units are available from Linde Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17.

U. S. P. Calcium Carbonate. Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, has announced that it is now producing U. S. P. grade calcium carbonate on a commercial basis. The product, available in 50-lb. bags, is expected to find application in processing antibiotics, pharmaceuticals and food products requiring the U.S.P. purity standards.

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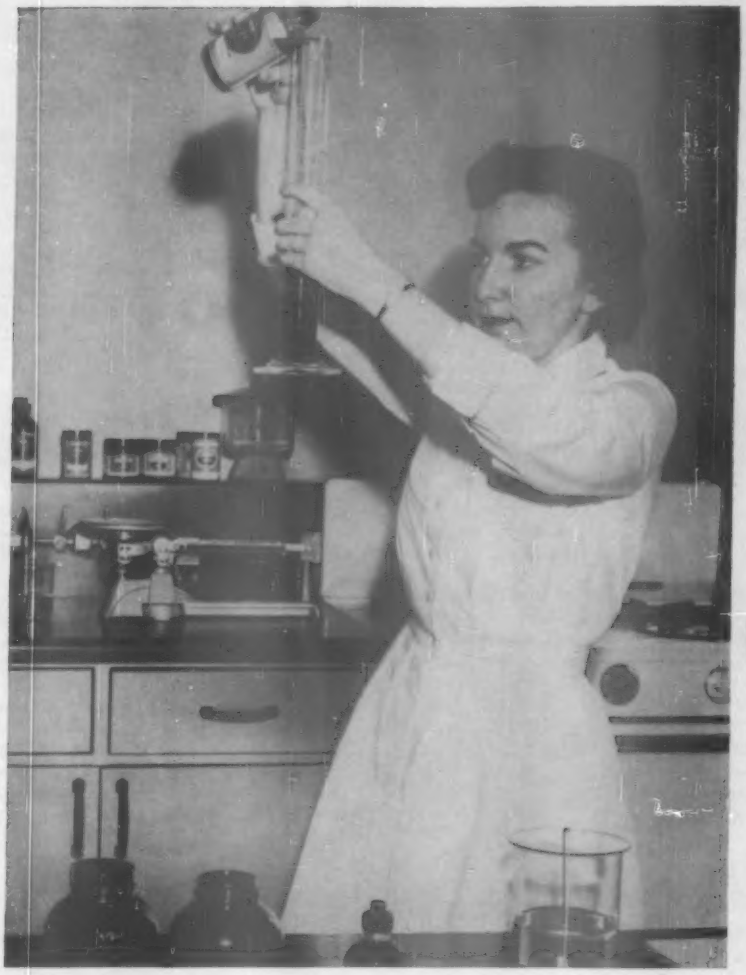

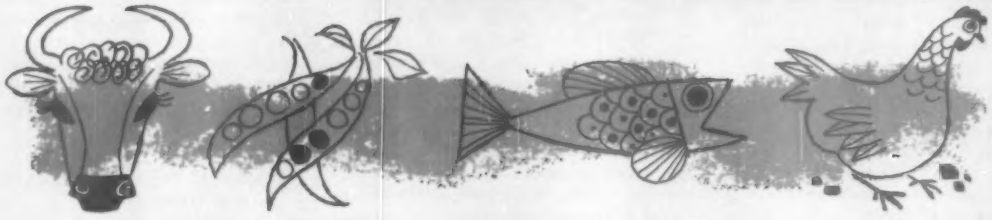

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(Continued from page 48)

FOOD AND FOOD TECHNOLOGY

Antioxidants

Effect of copper chelating agents on the pro-oxidant activity of ascorbic acid with unsaturated fats.

KELLEY, G. G. AND WATTS, B. M. (Florida State Univ., Tallahassee). *Food Research 22*, 308–15 (1957).

Nordihydroguaiaretic acid and certain flavonoid compds. were effective antioxidants and inhibited the pro-oxidant effect of ascorbic acid for prolonged periods of time. A Cu ascorbic acid complex was believed to be the causative agent for the pro-oxidant effect of ascorbic acid in aq. fat systems. The effective antioxidants were shown to be also capable of forming stable Cu chelates.

Coffee and Coffee Products

Functional differences between filtered and unfiltered coffee.

CZOK, G. AND LANG, K. (Physiol. Chem. Inst., Univ. Mainz, Germany). *Deut. med. Wochschr. 1956*, 1641–2; *Z. Lebensm. Untersuch. u. Forsch. 105*, 422 (1957).

Filtered coffee showed a greater production of acids in gastric juices while unfiltered coffee had a greater effect on the central nervous system and on physical activity.

Niacin content in coffee and its nutritional significance in Venezuela.

DAUM, M. G. (Inst. Nac. Nutrition, Caracas, Venezuela). *Arch. venezolanos nutric. 6*, 61–70 (1955); *Z. Lebensm. Untersuch. u. Forsch. 105*, 421 (1957).

Roasted ground coffee contained 33.9 mg%, brewed coffee, 1.9–3.0 mg% (percolator) and 2.4–3.4 mg% (coffee machine) niacin. Ext. of niacin depends upon the method of brewing and amts. to more than 80%. Higher roasting given Venezuelan coffee results in higher niacin levels in the brew. This together with a high coffee consumption makes coffee an important source of niacin.

Fats and Oils

Analysis of polyethylene glycol esters.

MALKEMUS, J. D. AND SWAN, J. D. (Jefferson Chem. Co. Inc., Austin, Texas). *J. Am. Oil Chemists' Soc. 34*, 342–4 (1957).

The products obtained by esterification of polyethylene glycols with fatty acid, or by means of the reaction of ethylene oxide with fatty acids, can be analyzed for their content of monoester, diester, and unreacted polyethylene glycol by taking advantage of the extractability of the polyethylene glycol with H_2O. A hot salt soln. is used to insure selective extn. Saponification and hydroxyl nos. are used to calc. the compn. of the mixt.; the mol. wts. of the acid and glycol are presumed to be known.

Fruits and Vegetables

Speeds fruit, vegetable ripening.

STEANERO, D. (McGraw-Hill World News, Rome, Italy). *Food Eng. 29*, 68–71, May, 1957.

Producers of fresh fruits and vegetables in Italy and France are now using an improved technique for quick ripening, extending storage, and fumigating their products. The technique makes use of biological processes which, as they occur in fruits and vegetables, consume O_2. They are regulated by controlling the amt. of O_2 supplied to the products.

Meat and Fish

Estrogen residues in meat. Public health aspects.

BRIGGS, G. M. (Public Health Service, U. S. Dept. of Health, Education, and Welfare, Bethesda, Md.). *J. Am. Med. Assoc. 164*, 1473–6 (1957).

The potential hazard of the practice of estrogen administration to animals lies in the possible exposure of personnel in manufg. plants and in the results of mistakes in mixing and feeding. These hazards can be carefully controlled, and, with the continued vigilance of feed manufacturers, state feed control officials, and the FDA, the use of estrogens in animal production provides an important tool for improved efficiency in food production.

Milk and Milk Products

Volatile carbonyl compounds produced in skimmilk by high-heat treatment.

MORGAN, M. E. (Storrs Agricultural Expt. Sta., Conn.). *J. Dairy Sci. 40*, 571–8 (1957).

Furfurnl and acetaldehyde are the principal volatile carbonyl compds. generated in skimmilk by high temps. None of the aldehydes which could come from a heat-induced reaction between leucine, isoleucine, or valine and the dicarbonyl compds. in raw and heated skimmilk was found in skimmilk heated for 90 mins. at 121° C. When leucine or isoleucine was added to raw skimmilks, 3-methylbutanal or 2-methylbutanal was isolated from distillates of the heated skimmilk.

Lipase systems used in the manufacture of Italian cheese. II. Selective hydrolysis.

HARPER, W. J. (Ohio State Univ., Columbus). *J. Dairy Sci. 40*, 556–63 (1957).

Crude lipase prepns. selectively hydrolyzed, at different rates, individual fatty acids from triglycerides. Pancreatic lipase liberated C-12 fatty acids or higher, that from *Aspergillus niger* released the lower ones, and milk lipase released both lower and higher acids. Lipases used in manufg. Italian cheese hydrolyzed much butyric acid which varied with the enzyme source.

Pectin

Pectic substances-water. II. Thermodynamics of water vapor sorption.

BETTELHEIM, F. A. AND VOLMAN, D. H. (Univ. of California, Davis). *J. Polymer Sci. 24*, 445–54 (1957).

A study of four polygalacturonides (highly esterified pectin) (I), enzymatically deesterified pectin, alk. deesterified Na pectate, and pure pectic acid (II) showed that swelling of the polymer during vapor sorption opened new polar groups for further adsorption for II and its Na salt. In contrast, I released no new polar group upon swelling showing that the Me group shielded carboxylic O from H-bonding with H_2O. The differential heat and entropy functions closely followed each other in the investigated systems. High negative differential entropy values were explained by the contribution of solid polymer which showed increasing order as indicated by an increase in crystallinity during the H_2O vapor sorption.

Potatoes

Influence of gamma irradiation of potato tubers on the rate of respiration.

GUSTAFSON, F. G., BROWNELL, L. E., AND MARTENS, R. A. (Plant Products Branch, Quartermaster Food & Container Inst. of the Armed Forces, Chicago, Ill.). *Am. Potato J. 34*, 177–82 (1957).

Gamma-irradiation of potatoes with dosages of 5–15 kilorep inhibit sprouting over a period of 22 weeks, produce little or no alteration in physical appearance of the tubers and after an early spurt in respiration settle down to a rate very nearly that of the non-irradiated controls. Higher dosages caused disturbances as browning, blackening, fungus infection, and an increase in respiration, which continued throughout the investigation.

Absence of thermal polymers in potato-chip frying oils.

MELNICK, D. (The Best Foods, Inc., Bayonne, N. J.). *J. Am. Oil Chemists' Soc. 34*, 351–6 (1957).

The problem of thermal polymers of acceptable flavor in potato-chip-frying oils was discussed from the standpoint of potentiality of such polymers forming during com. frying operations. Publications on heat-abused oils were critically reviewed, and many of these were shown to yield findings irrelevant to practical operations.

Poultry

An enteric growth factor for chicks.

ANDERSON, H. J., VACANTI, J. J. AND LIND, M. C. (Division of The Cudahy Packing Co., Omaha, Nebraska). *Poultry Sci. 36*, 675–6 (1957).

The report covers a new growth factor (or factors)—enteric growth factor, de-

rived from the swine intestinal tract, and as yet unidentified, but which, when added to a complete chick starter com. ration, as the basal, gave a very good growth response.

Effect of meprobamate on growth and feed efficiency of chickens.

BABCOCK, M. J. AND TAYLOR, M. W. (Rutgers Univ., New Brunswick, N. J.). *Poultry Sci. 36*, 485–7 (1957).

Feeding the tranquilizer meprobamate (Miltown) to White Leghorn cockerels produced no visible effect other than growth inhibition at relatively high levels of 0.6 to 2.2%.

Starches

Microstructure of starch grains.

ROBERTS, E. A. (17 Dearborn St., Salem, Mass.). 1956, 45 pp. (published separately).

A study of the structure of starch with 123 microphotographs and 119 references. Use was made of high energy cathode rays and the ultraviolet microscope to contribute to the microphysical and microchemical structure of starch. It was concluded that the microphysical structure of the starch grain is identical with that of the plastid in which it is formed. The plastid, after starch formation is the starch "grain" or framework. The structure of the plastid is relatively permanent, while the "starch substance" held to the reticulated protoplasmic framework is much more readily removable by the effect of temp., enzymes, or irradiation, thus accounting for many apparent anomalies observed on degraded or treated starch. The marking or striations on starch grains are due to the structure of the plastid. High energy cathode rays convert some of the starch to dextrin, glucose, and fructose without destroying the basic structure of the starch grain. The threshold value for the same effect produced by irradiation is about 5×10^6 rep. For cold sterilization of foods contg. starch, no change in the starch will occur with an irradiation dose of $< 4\text{–}5 \times 10^6$ rep. Since starch grains contain not only carbohydrates but also the protoplasmic framework of the plastid in which they were formed, consideration must be given to the overall or combined effect of these in technological treatment of starch. The size starch unit is not definitely known, however, units of at least 100 A indicate starch.

Molecular weight heterogeneity in starch amylopectins.

STACY, C. J. AND FOSTER, J. F. (Purdue Univ., Lafayette, Indiana). *J. Polymer Sci. 25*, 39–50 (1957).

The no. av. mol. wt. of a corn amylopectin sample is concluded to be approx. 300,000 on basis of both osmotoic pressure and reducing group detn. The wt. av. mol. wt. of this prepn. was previously shown to be approx. 80×10^6. The ratio of M_w/M_n is in accord with that expected on the basis of an essentially random synthesis of the branched polymer. Further evidence for an extreme heterogeneity in amylopectins is provided by light scattering studies on subfractions prepd. by fractional centrifugation. Conclusive evidence for this broad heterogeneity is obtained by ultracentrifugal analysis. The distribution of sedimentation coeff. is shown to be extreme, significant percentages of the polymer having sedimentation consts. ranging from almost zero to above 400 Svedberg units. Some observations on the sedimentation behavior of other amylopectins, their β-amylase limit dextrins, and corn amylose are given.

Taste and Taste Testing

A modified latin square design for taste-testing.

FERRIS, G. E. (General Foods Corps., Research Center, Tarrytown, N. Y.). *Food Research 22*, 251–8 (1957).

In this article a special design is described for use by expert (booth) panels. It is intended to be used for evaluating flavor differences among 2–7 samples in such a way that all foreseeable sources of error are controlled, e.g. panel fatigue, order of presentation, and, as the special feature, after-taste effects. The choice of possible designs and methods of analysis are given.

PHYSICAL RESEARCH

Enzyme models. IV. Kinetics of the catalyzed decarboxylation of benzoylformic acid.

ENDLER, A. S. AND BECKER, E. I. (Polytechnic Inst. of Brooklyn, N. Y.). *J. Phys. Chem. 61*, 747–52 (1957).

The rate of decarboxylation of benzoylformic acid in phenol soln., catalyzed by 3-aminoöxindole, α-phenylglycine and related compds. was studied. The range of temp. was 50 to 100°. α-Phenylglycine is *ca.* 1/15 as effective as 3-aminoöxindole and 3-methyl-3-aminoöxindole is ineffective. These data require a prototropic rearrangement in a Schiff base intermediate and make feasible an open-chain transition state as well as the cyclic one proposed earlier.

STATISTICS

Estimating the service life of household goods by actuarial methods.

PENNOCK, J. L. AND JAEGER, C. M. (Inst. of Home Economics, U.S.D.A.). *J. Am. Statistical Assoc. 52*, 175–85 (1957).

Although this article deals with the service-life expectancy of furniture under one owner, the method used could be applied to establish the av. life on shelves of food-products. Instead of following through the life-stories of a representative sample of products (e.g. by telephone interviews of the "have you used it yet?" type), which is not only costly but hard to do without biasing the results, one takes a cross-section in time. By tabulating inventory and discards on consumption, one can arrive at the estimate of av. shelf life with a few reasonable assumptions. One would use weeks (or months) as units for food products in place of years, as is done in the article.

PATENTS

Preparation of starch from starch bearing plant materials by pectic enzymes.

DAMODARAN, M. AND BABBAR, I. Assignors to Council of Scientific and Industrial Research. U. S. 2,801,954, August 6, 1957.

A method of recovering starch from starch bearing plant materials in which the starch is at least partly enveloped by pectic substances, comprising the steps of treating the plant material with pectic enzymes obtained from a culture of a pectic enzyme-producing microorganism belonging to the group consisting of *Aspergillus aureus, Aspergillus niger, Aspergillus wentii, Botrytis cinera, Penicillium chrysogenum* and *Rhizopus tritici* whereby the pectic substances enveloping the starch without substantially altering its condition; and sepg. the thus liberated starch from the remainder of the reaction mass.

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American Maize Products Company.....39
American Optical Company.....18
American Spice Trade Association.....30
Association of American Soap & Glycerine Producers, Inc.....17

Continental Can Company.....31
Corn Products Sales Company..... 2

Dairyland Food Laboratories, Inc.....70
Distillation Products Industries.....6..&..7
Dodge & Olcott, Inc.....37
E. I. du Pont de Nemours Company, Inc. 44
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Firmenich, Inc. 29
Florasynth Laboratories, Inc.....3rd Cover
Food Development Laboratory.....70
Food Machinery & Chemical Corporation 34
Food Research Laboratoriees, Inc.....70
Fritzsche Brothers, Inc.....43

Givaudan Flavors, Inc.....23
The Griffith Laboratories, Inc.....14

Hercules Powder Company.....65
Hoffmann-La Roche, Inc. .....19 & 20

Klenzade Products, Inc.....24
Knickerbocker Mills Company.....54
H. Kohnstamm & Company, Inc.....61

Manton- Gaulin Manufacturing Company 47
Morton Salt Company.....13

The Nestle Company..... 9
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Chas. Pfizer & Company, Inc.....2nd Cover

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Sheffield Chemical 57
A. E. Staley Manufacturing Company..59
Wm. J. Stange Company.....41
Sterwin Chemicals, Inc.....51 & 52
Sunkist Growers, Inc.....27

Truesdail Laboratories, Inc.....70
S. Twitchell Company.....10

Ungerer & Company, Inc..... 5
U. S. Stoneware Company.....49
U. S. Testing Company.....58

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Vanilla Laboratories, Inc.....36

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Trust Norda to know, and to tell you, and to make you a flavor you want. Your letterhead will bring you free samples of Norda Flavors for quality foods.

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